Power Engineering

Combining POWER PLANT ENGINEERING and POWER GENERATION

FOR ALL POWER ENGINEERS • STEAM, ELECTRICITY AND ALL OTHER POWER ENGINEERING SERVICES

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The PRACTICAL ENGINEER and ELECTRICIAN

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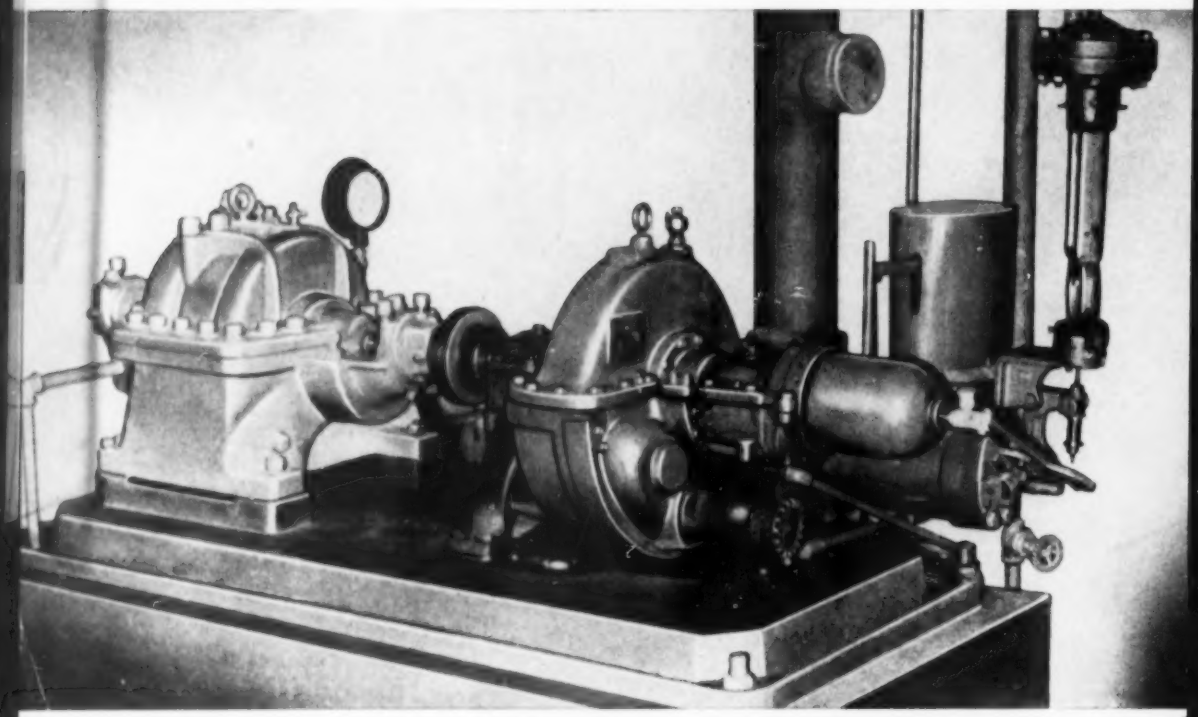
MAY 1950

TECHNICAL PUBLISHING COMPANY • CHICAGO, ILLINOIS

Maintenance men

"BEST CONSTRUCTED PIECE OF EQUIPMENT I'VE EVER WORKED ON" said maintenance engineer Johnson about the Elliott turbine in the photo below. "It's particularly quiet and smooth in operation. There's a lot of machine here! We're very proud of it." The turbine drives a boiler-feed pump in the Standard-Coosa-Thatcher Company National Plant, Rossville, Ga.



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know the answer

A machine that gets the whole-hearted approval of the maintenance staff, has passed the acid test of mechanical equipment. This is so generally the case with Elliott YR turbines that the matter is no longer in question. Reports like that on the opposite page come in constantly.

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H-726

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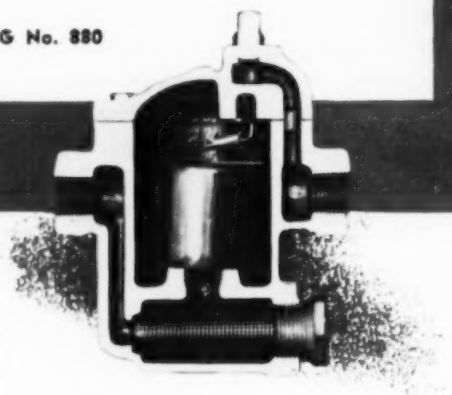

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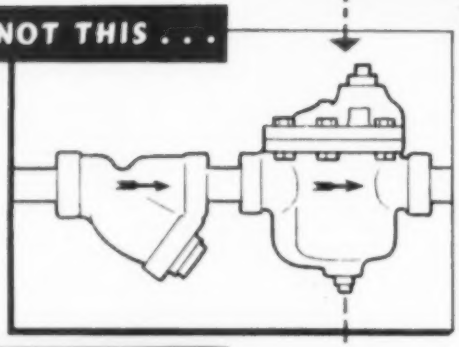

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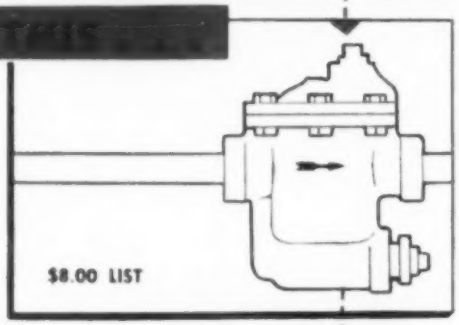

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THE No. 880 is available with ½" or ¾" connections for operating pressures to 150 psi; 450 to 690 lbs/hr continuous discharge capacity. 5⅞" high; 5" diameter; weight 5 lbs. One of a complete line of traps described in the ARMSTRONG STEAM TRAP BOOK. Send for your copy.

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Power Engineering

Combining POWER PLANT ENGINEERING and POWER GENERATION

May 1950

VOLUME 54—NUMBER 5

Notes on This Issue

POWER ENGINEERING—a better title

Very few readers or advertisers will ask "Why?" this change in the name of an old established publication from *Power Generation* to *Power Engineering*.

Many of you will recall that the old name *Power Plant Engineering*, used since 1918, was changed in January 1948 to *Power Generation* as part of our plan to start the new publication, *Plant Engineering*. The *new* magazine covers the function of plant engineering in industry, a function separate and distinct from power engineering and *Plant Engineering* is the perfect title for that field. The rapid success of the new magazine is proof of the rightness of the functional analysis.

We had planned in 1947 to create two new titles, *Plant Engineering* and *Power Engineering* from the old title, *Power Plant Engineering*.

However, it was decided to use *Power Generation* instead of the title *Power Engineering* because at the time it seemed more specific.

After two years it is evident that the name *Power Generation* is interpreted by many as *restrictive* rather than specific and the impression has been gained that the old publication under the title of *Power Generation* was *narrower* in scope than *Power Plant Engineering* had been. This is not the case. It is the same magazine which for years has served the entire field of power engineering.

So the only sensible thing to do in fairness to readers, advertisers and ourselves is to go back to the title *Power Engineering* as originally planned in 1947. This title accurately describes the field and function served and indicates the continuity from *Power Plant Engineering*.

We were "right the first time" and are sure that *Power Engineering* is established as the title for many years to come.

The "Practical Engineer" section is back

The *Practical Engineer* was the name of this magazine from 1896 to 1918 when the name became *Power Plant Engineering*. In July 1939 we brought the *Practical Engineer* back as a *special section* devoted to the work-a-day problems of power engineers—all those practical daily operation and maintenance matters that are so important in every power plant.

In July 1949 our reader calls seemed to indicate that a change in presentation was desirable so the *Practical Engineer* material was dispersed throughout the editorial pages instead of grouped in the separate section.

But the reader is our boss and the demand from readers is clear and emphatic. They want the *Practical Engineer* section back again so here it is, expanded, improved and streamlined as ordered.

How do you like this month's cover?

We pioneered the idea of *complete* contents on the front cover. POWER ENGINEERING has a wide use for reference and when an engineer is looking over back issues for a particular article he really appreciates the contents cover. This month we have injected more punch and readibility into the cover by using stronger type effects, without impairing the reference or recognition value.

WHEN YOU PURIFY OIL

REMOVE BOTH DIRT AND WATER

Turbines require protection from two different causes of lubrication failure — ***dirt*** and ***water.*** Removal of dirt alone merely does half a job. That is why De Laval Oil Purifiers are so much more effective for maintaining turbine oil than any other means available. They instantaneously remove solid foreign matter and any moisture that may be present as well.

It is extremely important to get this ***double*** protection, for water is the real trouble-maker as often as not. For example, condensate in oil leads directly to the formation of sludge, and of course there is always the possibility of a major water leak which might lead to serious emulsification and very real trouble.

De Laval Oil Purifiers do not remove oil-soluble additives; action within the centrifuge is entirely mechanical.

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ENGINEERS' PREVIEW

FIVE RECENT REPORTS on company pension planning form one of the most comprehensive discussions of the subject now available. These five reports by fire different authors, all authorites in the field of pensions, industrial relations and industrial insurance, cover fundamental considerations in establishing pension programs, factors in company pension costs, background and principles of standard pension practices, selling the company pension program to employees and methods of funding pension plans.

If your company is considering establishment of a pension plan, these reports may be very helpful to you. They may be obtained for $1.00 each or $3.50 for the set of five reports, postpaid anywhere in the United States. To get them, send direct to Research Division, California Personnel Management Association, 442 Flood Bldg., 870 Market Street, San Francisco 2, Calif. We do not have any copies of these for sale or distribution, so please do not send us any money for them but write direct to the Association.

★ ★ ★

SOMETHING NEW in acid-type storage batteries has made an appearance. The battery consists of three concentric cells within a single cylindrical rubber or glass casing. Among the advantages claimed are less weight, better resistance to breakage and lower fabrication costs.—*The Ohmite News.*

★ ★ ★

EVER HEAR OF a pump operated entirely by sound waves? Well, a sonic pump has been tried by oil well drillers in California to lift crude oil from the depths. In this device, sound waves cause alternate contraction and expansion of the drill tube sufficient to force fluids up the pipe. Of course, it is still experimental.

But if you think that is a queer one, some of these oil well drillers have now turned to ice cream as vital equipment in their search for new oil deposits. Old-time, hard-bitten wild-catters turn green at the thought! The drillers use a spinner—an instrument to determine at what depth water enters a completed well—and they needed something to protect it—so they dumped ice cream down on top of it. They are now working to substitute oleomargarine for the ice cream because the oleo is easier to transport and store in hot weather. Also, it would not be eaten so rapidly by the sun-baked drillers.

★ ★ ★

WIRED TELEVISION has pushed its way into industry very rapidly within the past year or two and now it is possible for you to see operations going on where you can't look yourself because it is too dangerous, too difficult, too expensive, too far, too hot, too cold, too dark. A new catalog of Diamond Power Specialty Corp. describing its Utiliscope, shows 16 different ways in which the device may be used in industry for protection, cutting costs, eliminating hazards and the like.

Another interesting development in wired television is the RCA Vidicon, a new and very small pickup tube that may drastically cut the size and weight of sending and receiving units in plant television. It results in a pickup set about the size of a 16-mm home movie camera, weighing about 8 pounds.

HIGH-HEATING-VALUE briquets can be made from the "slacks" or "fines" of sub-bituminous coals, according to a brief review of this field released by the Office of Technical Services of the U. S. Department of Commerce. Findings of the study indicate that profitable operation of briquetting plants near mine locations may be possible. Publication PB 99806, Briquetting of Dried Low-Rank Western Coals, is available from the Office of Technical Services, U. S. Department of Commerce, Washington, D. C., at $2.25 per copy.

★ ★ ★

TODAY, as in ages past, man is almost completely dependent upon solar radiation—both that which has been stored during the centuries in such forms as coal, oil, peat, and gas, and that which is currently being converted to plants and other vegetable life through the process known as photosynthesis. Yet the earth's stores of natural fuels are gradually being used up, and after countless years on this planet man has scarcely begun to make efficient use of the solar energy daily shed upon the earth. But science is turning to the problem.

In recent experiments with controlled photosynthesis, Stanford Research Institute research men have improved on plant utilization of solar energy to create organic food stores. In experiments with the alga *chlorella*, chemical engineers at Stanford Research Institute have succeeded in utilizing 5 per cent of the incident sunlight, or over 2 per cent of the total solar radiation.

★ ★ ★

MOST OF US are familiar with two or three types of nails. It is surprising to learn that there are more than 50 different styles of nails, not including staples and tacks. They come blued, silvered, coppered, black or in stainless steel. The points may be duckbill, needle, diamond; or the nails may be pointless. The heads may be button heads, rose heads, oval heads, flat heads—or no heads. Some of the common nails are known as berry box, broom, beer case, orange crate. Hungarian nails (for work shoes), egg case nails, and channel nails.—*The Ohmite News.*

★ ★ ★

EVEN THOUGH man has learned to fly faster than sound can travel, the bulk of this country's combat aircraft will still be subsonic for many years to come, the ASME was told at its recent spring meeting in the Hotel Statler, Washington, D. C. Carl C. Sorgen, technical assistant to the head of the Experimental Engines Branch, Bureau of Aeronautics, Department of the Navy, said the brute force required for propulsion beyond the sonic barrier made supersonic aircraft "tremendously expensive."

Mr. Sorgen said two exceptions will be made—high performance interceptor fighters and guided missiles—and in these cases pure jet propulsion will be used, either in the form of the turbojet, ramjet or rocket, to attain supersonic speeds. In the subsonic field, he said, it appears that the gas turbine engine will be used for everything but the "slow freight" aircraft.

"The main question remaining to be answered, then, is whether to use the gas turbine engine with or without a propeller," said Mr. Sorgen.

NATIONAL SAFETY COUNCIL has just notified the du Pont Company that its plants have won the top honors for 1949 in all three groups of Division 1 in the Chemical Section safety contest of the Council. Altogether, 64 of the company's operations won perfect-record trophies and special awards. Sixty-two of them operated throughout the entire year without a single lost-time injury to employees.

★ ★ ★

DURING the past few years, the general style, readability and attractiveness of the average company report have increased, if our 7-place logarithm tables may be trusted, by exactly 2856.548 per cent. The average reader of *Power Engineering* is probably not so conscious of this as we are, for he probably sees only the reports of his own and a few other companies. But over the years, we receive in this office a steady stream of annual company reports—dozens of them.

For sheer good looks, nothing we have seen so far beats the annual report of the Eastman Kodak Company for 1949.

As you might expect, with the resources of the company behind it, this report is illustrated with both black and white and color photographs that will make every amateur photographer drool. The front cover shows a familiar view in Rockefeller Center Plaza in the springtime; you probably remember the colors of the flowers and the bank of colorful all-nations flags on display there. Especially noteworthy in the report is a page showing a typical commercial use of the new Kodak Flexichrome Process for making color prints from black-and-white negatives. The work of the company is described and the financial data are presented in the English language. A carnation to EK Co. for this one.

★ ★ ★

JAMES D. CUNNINGHAM, president of Republic Flow Meters Co., has been awarded the Chicago Technical Societies Council 1950 Merit Award for outstanding engineering, administrative and civic service. Mr. Cunningham is also president of the ASME for 1950, and has been chairman of the Board of Trustees of Illinois Institute of Technology since its formation in 1940.

★ ★ ★

ALTHOUGH MANY factors have contributed to the advancement of scientific and technological knowledge, none stand out as more significant than the computing machine. Such machines are either of the arithmetical type or of the continuously-acting type, such as the electronic analogue computer and various electro-mechanical devices. Engineers have been hearing a great deal about these; but for the most part, outside the strictly scientific fields, most of the information published has been of the sunday supplement type, oh-ing and ah-ing at the marvelous results these machines can accomplish.

But exactly how do they do it? Well, that is too long a story for even a good many scientific magazines. But, for the first time, engineers may be able to get some idea of how these electronic computers work from an interesting article in the March 1950 issue of *The Frontier*, published by Armour Research Foundation of the Illinois Institute of Technology. In this article are shown several algebraic equations and a couple of integral equations, with the corresponding electrical components and circuits set up for solving them in a computing machine.

SEVERAL MONTHS AGO, the scientific and engineering worlds were all agog over the announcement of a new compressed air device consisting of a tube, supplied at the middle with high pressure air, and exhausting cold air at one end of the tube and hot air at the opposite end. Known by various names, this tube is actually the Hilsch Vortex Tube. It was described in *Industrial and Engineering Chemistry*, May 1946, also in *Popular Science*, May 1947, and mention was made of it in *Power Generation*. More recently the du Pont Engineering Research Laboratory has studied the operation of this tube and now advances an explanation of why it works as it does.

For there is no doubt that the tube does produce hot air at one end and cold air at the other, and if you are interested in a detailed explanation of its action, you will find it in a paper by D. S. Webster entitled, An Analysis of the Hilsch Vortex Tube, included in the Journal of the ASRE, *Refrigerating Engineering*, February 1950. The Hilsch Tube may eventually emerge from the category of a laboratory toy to become a practical device with reasonably economical operation in some specialized application. The analysis of its action is still controversial but worth considerable thought and study.

★ ★ ★

GOULD PAPER CO. has sold its 50-year-old electrical distribution system to Niagara Mohawk Power Corp., according to a recent AP report. The system serves 716 customers in Lyons Falls, Turin, Constableville and adjoining rural areas in New York.

★ ★ ★

A PANEL of engineers and business men, headed by Dr. Vannevar Bush, called today for the training of "a new type of engineer, known for his grasp and versatility in many fields."

In a report to the Harvard Corporation, the panel declared that "there is an increasing need for men of broader training in engineering and applied science, broader without being superficial, to become leaders in an expanding economy based increasingly upon the utilization of science in an economic manner for human needs."

The panel was appointed by President Conant last summer to advise the University on how best to use the income from the $15,000,000 endowment left by the late Gordon McKay "to promote applied science."

A man with a real grasp of thermodynamics can use it in connection with heat engines, chemical engineering or even biology. This same conception was brought out by Professor Kimbark of Northwestern in his new book, Electrical Transmission of Power and Signals, reviewed on page 98 of our April issue. He points out that the basic theories of electrical transmission are fundamentally the same in the three fields of power, telephone communication and ultra-high frequencies, that there is no need for studying them separately in each of those fields and that the book attempts to avoid such duplication of effort. It is this type of thing that the Harvard panel has in mind.

★ ★ ★

COLOR TELEVISION is brought closer by a new filter recently developed by Bausch & Lomb Optical Co. The filter employs three thin films of silver and magnesium fluoride, applied under high vacuum to one side of the tube. The thickness of the magnesium fluoride film determines which color will pass through the filter. A large set of these filters is now in use at the Royal Observatory, Copenhagen, Denmark, for research on the color of interstellar matter.

DIESELS RUN CLEANER...

...and fuel costs are less when you lubricate with Texaco Ursa Oils

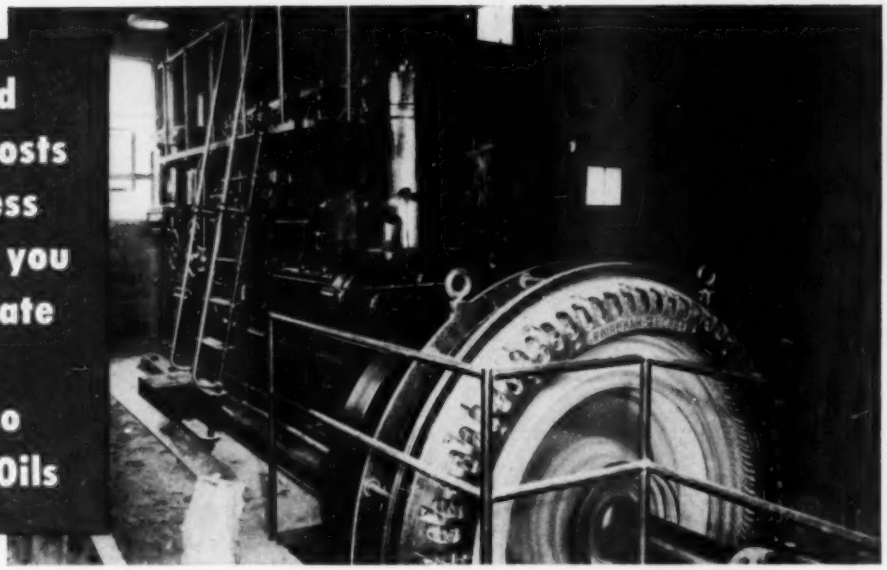


Photo courtesy Fairbanks, Morse & Co.

ANY Diesel lubricated with *Texaco Ursa Oil* is bound to run cleaner because *Texaco Ursa Oils* have high resistance to oxidation . . . and are designed to keep harmful carbon, sludge and varnish from forming. So rings stay free, valves work the way they should, ports stay open . . . assuring better compression and combustion.

In addition, *Texaco Ursa Oils* maintain their tough lubricating films in spite of heat and high pressure. Wear all but vanishes. Bearings and all moving parts last longer. No wonder maintenance costs and fuel consumption are less when *Texaco Ursa Oils* are on the job!

There is a complete line of *Texaco Ursa Oils*. They are approved by leading Diesel manufacturers, and are easily America's favorite Diesel lubricants – as shown by the fact that *more stationary Diesel h.p. in the U. S. is lubricated with Texaco Ursa Oils than with any other brand.*

Get a greater return from your Diesel operating dollar. A Texaco Lubrication Engineer will gladly help you. Just call the nearest of the more than 2,000 Texaco Wholesale Distributing Plants in the 48 States, or write:

The Texas Company, 135 East 42nd Street, New York 17, N. Y.

TEXACO

TEXACO Ursa Oils

FOR ALL DIESEL ENGINES

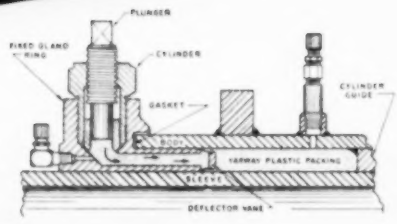
TUNE IN . . . TEXACO STAR THEATER starring MILTON BERLE on television every Tuesday night. See newspaper for time and station.

GUN-PAKT EXPANSION JOINTS

to maintain

require

for servicing



Close-up of cross-section showing detail of Gun-Pakt feature.

YARWAY

Maintenance costs are less because there's less maintenance.

In a nutshell, that's why more and more utilities, institutions and industrial plants distributing steam are turning to Yarway Gun-Pakt Expansion Joints.

Servicing Gun-Pakt Joints never interrupts heating or production. They are serviced under full steam pressure, without shutdowns.

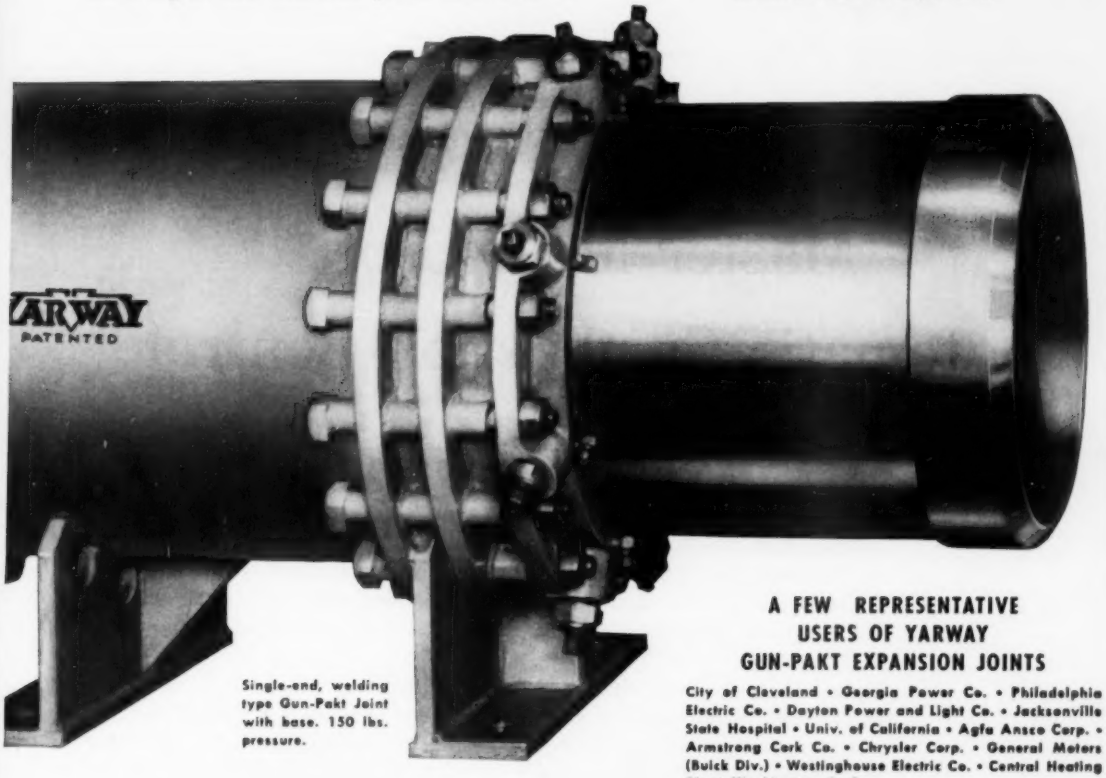
To repack a Gun-Pakt Joint you simply insert a plug of plastic packing, turn a wrench, and the job's done. Special Alemite fittings provide for proper lubrication.

Users report that Gun-Pakt Joints cost little to maintain. One who has kept accurate records says "65 cents per year per joint." Others claim even less.

Available with single or double ends, welding or flanged types, in sizes from 2" to 30", with traverses from 4" to 24", and for pressures to 400 psi.

For the full Gun-Pakt story, as well as information on other Yarway slip-type joints, write for Yarway Bulletin EJ-1912.

YARNALL-WARING COMPANY
114 Mermaid Avenue, Philadelphia 18, Pa.
Branch Offices in Principal Cities



Single-end, welding type Gun-Pakt Joint with base. 150 lbs. pressure.

A FEW REPRESENTATIVE USERS OF YARWAY GUN-PAKT EXPANSION JOINTS

City of Cleveland • Georgia Power Co. • Philadelphia Electric Co. • Dayton Power and Light Co. • Jacksonville State Hospital • Univ. of California • Agfa Ansco Corp. • Armstrong Cork Co. • Chrysler Corp. • General Motors (Buick Div.) • Westinghouse Electric Co. • Central Heating Plant, Washington, D. C.

For any fuel or combination of fuels

The HAGAN Differential Master Method of Automatic Combustion Control

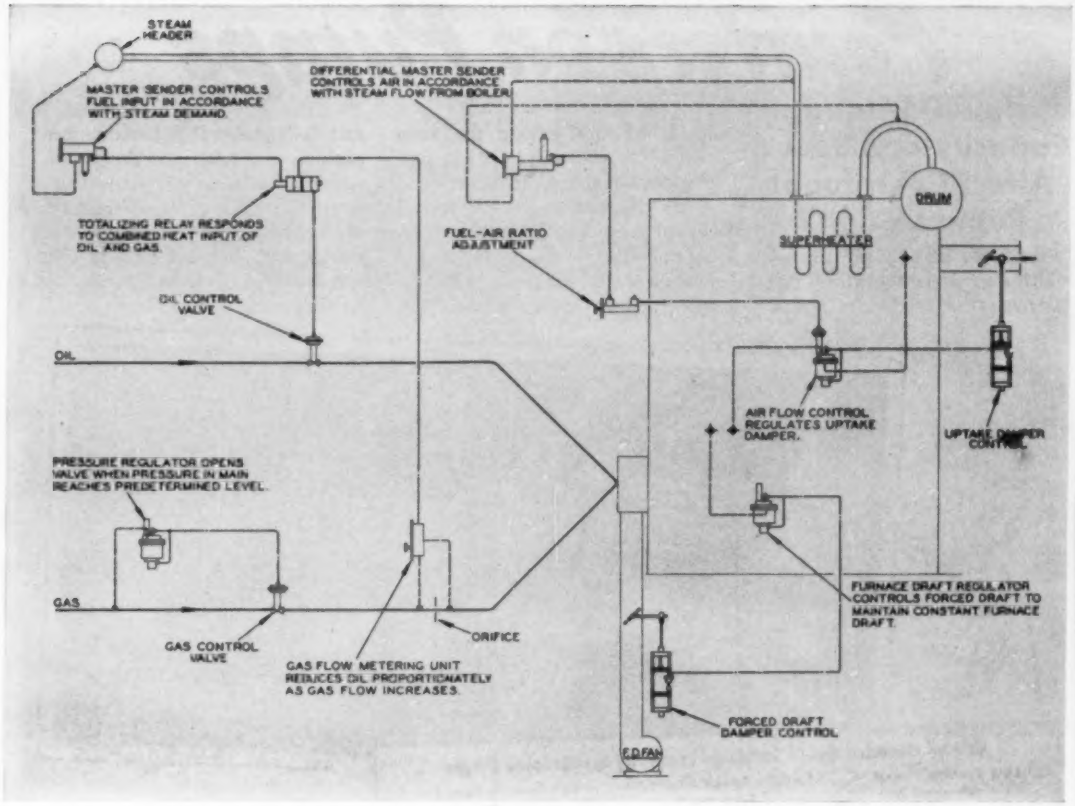
In many installations, fuel economy demands that boilers be able to use two, three or even more fuels, either singly or in varying combinations. Heat input may not remain at a constant rate, because of variations either in calorific value of the fuel, or in operation of feeding mechanisms.

Under such conditions, however, the Hagan Differential Master method of combustion control automatically maintains proper combustion conditions in a simple and direct way, using the boiler unit itself as a calorimeter of heat input to establish the correct air requirements.

A Master Sender, sensitive to steam header pressure, regulates the rate of fuel feed so that Btu input is in accordance with demand.

A Differential Master Sender, measuring steam flow, regulates air flow.

HAGAN
HALL
BUROMIN
CALGON


STEAM HEADER
MASTER SENDER CONTROLS FUEL INPUT IN ACCORDANCE WITH STEAM DEMAND.
DIFFERENTIAL MASTER SENDER CONTROLS AIR IN ACCORDANCE WITH STEAM FLOW FROM BOILER.
TOTALIZING RELAY RESPONDS TO COMBINED HEAT INPUT OF OIL AND GAS.
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DRUM
SUPERHEATER
OIL CONTROL VALVE
OIL
AIR FLOW CONTROL REGULATES UPTAKE DAMPER.
UPTAKE DAMPER CONTROL
PRESSURE REGULATOR OPENS VALVE WHEN PRESSURE IN MAIN REACHES PREDETERMINED LEVEL.
FURNACE DRAFT REGULATOR CONTROLS FORCED DRAFT TO MAINTAIN CONSTANT FURNACE DRAFT.
GAS
ORIFICE
GAS CONTROL VALVE
GAS FLOW METERING UNIT REDUCES OIL PROPORTIONATELY AS GAS FLOW INCREASES.
FORCED DRAFT DAMPER CONTROL
F.D.FAN

These units are not interconnected. Each has its own function, and performs that function **directly.** The rate of fuel feed is changed instantly to compensate for any change in steam demand or variation in calorific value of fuel or in feeder characteristic. Air, however, is changed only when there is an actual change in steam flow.

Control is direct and accurate. There is no necessity for approximate adjustment, to be corrected by a lagging corrector system. Fuel savings are substantial.

Our engineers will be glad to discuss the advantages which the Hagan Differential Master System offers for your plant. Hagan Corporation, Hagan Building, Pittsburgh 30, Pa.

HAGAN CORPORATION

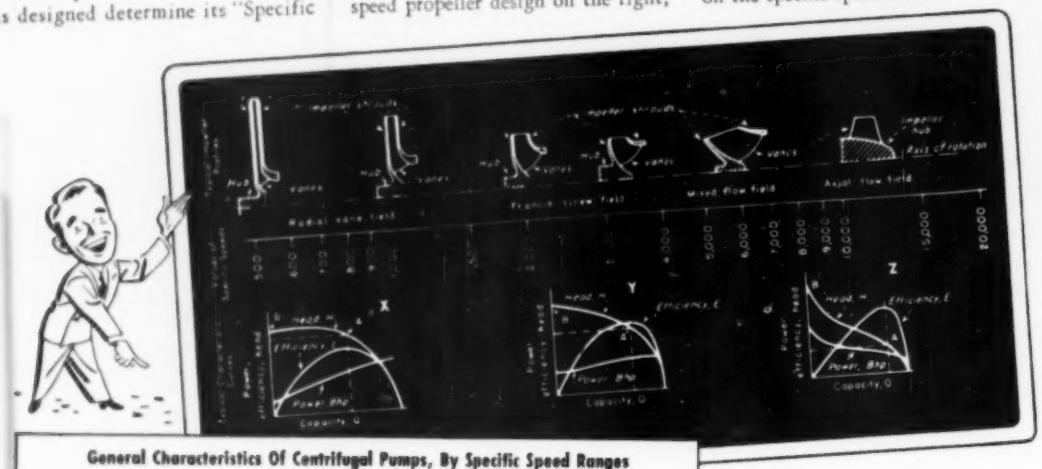
BOILER COMBUSTION CONTROL SYSTEMS
RING BALANCE FLOW AND PRESSURE INSTRUMENTS
METALLURGICAL FURNACE CONTROL SYSTEMS
THRUSTORQ FORCE MEASURING DEVICES

Pointers on Pumps

How Do Head, Capacity and Speed Affect Centrifugal Pump Design?

The head, capacity and speed for which a particular centrifugal pump is designed determine its "Specific Speed." Pumps having the same "Specific Speed" will have like proportions and characteristic curves.

The illustration shows several typical pump-impeller profiles, ranging from the low specific speed radial flow on the left to the high specific speed propeller design on the right, each design being placed in its proper position with relation to the specific speed scale. Below the scale, characteristic curves X, Y and Z indicate the hydraulic characteristics of three pumps, each designed for a specific speed corresponding to its position on the specific speed scale.



General Characteristics Of Centrifugal Pumps, By Specific Speed Ranges

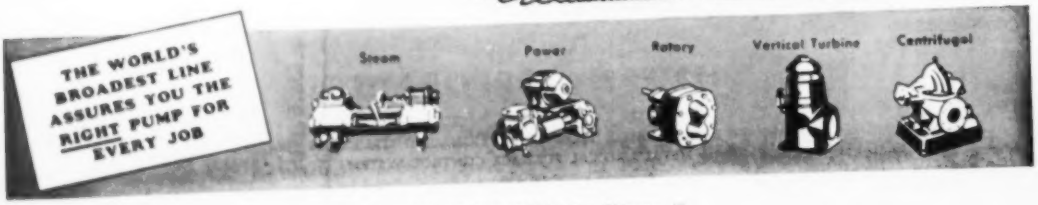
Low Specific Speed — Diagram X	Medium Specific Speed — Diagram Y	High Specific Speed — Diagram Z
Small rise in head from point of maximum efficiency "A" to shut-off "B".	Steeper rise in head from "A" to "B".	Very steep rise in head from "A" to "B".
Wide capacity range at high efficiency.	Moderate capacity range at high efficiency.	Narrow capacity range at high efficiency.
Rapid decrease in bhp from point of efficiency "A" to shut-off "B".	Nearly constant bhp from "A" to "B".	Rapid increase in bhp from "A" to "B".

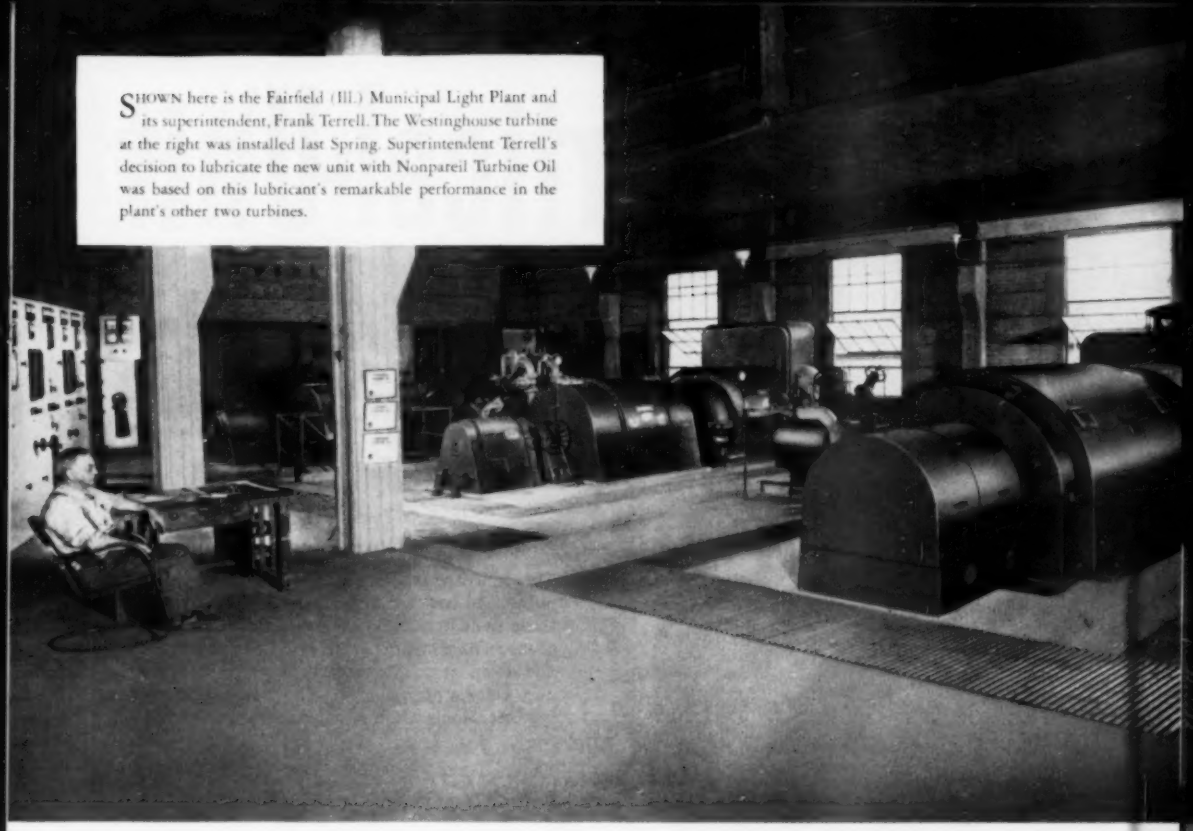
These basic characteristics may be modified to obtain certain desirable features. For example, although boiler feed pumps have low specific speed, they require a steadily rising head-capacity curve — not one that droops toward shut-off, as shown. There can be any number of pump designs in-between and beyond the few typical ones illustrated here.

You'll Find the Right Pump in the Worthington line — the world's most complete. Another reason why *there's more worth in Worthington* is the expert technical advice, backed by over 100 years of experience, that is always available to you. Just contact your nearest District Office, or write to *Worthington Pump and Machinery Corporation, Centrifugal Pump Division, Harrison, New Jersey.*

WORTHINGTON

co-2





SHOWN here is the Fairfield (Ill.) Municipal Light Plant and its superintendent, Frank Terrell. The Westinghouse turbine at the right was installed last Spring. Superintendent Terrell's decision to lubricate the new unit with Nonpareil Turbine Oil was based on this lubricant's remarkable performance in the plant's other two turbines.

Here's <u>minimum</u> turbine-oil maintenance

CENTRIFUGING once a year is the only turbine-oil maintenance found necessary at the Fairfield Municipal Light Plant, Fairfield, Illinois. This practice has been followed ever since 1940, when Nonpareil Turbine Oil first went into the plant's new 1500-KW Westinghouse turbine. The same routine has been employed on a second Westinghouse unit of 2500 KW, installed in 1942.

During these 8 and 10 years of operation, the original fills of Nonpareil have not been removed either for treating or for replacing. Neutralization numbers have stayed below 0.08 mg KOH/gm. Oil systems have remained entirely clean.

Such lubricating economy and efficiency is not limited to 10- or 15-year records with Nonpareil Turbine Oil. Each fill of Nonpareil carries a written guarantee that it will remain below a neutralization number of 0.15 mg KOH/gm. *for the life of the turbine* it lubricates. 21-year service records of Nonpareil provide evidence of its ability to end acidity trouble and oil maintenance once and for all.

A Standard Oil Lubrication Engineer will be glad to supply you with actual case histories of utility operations in which Nonpareil Turbine Oil has reduced lubrication costs as much as 68%. Your letter will obtain the Engineer's services.

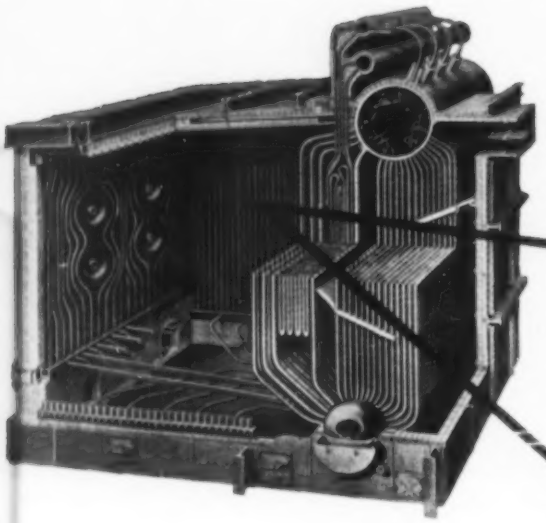
Write Standard Oil Company (Indiana), 910 South Michigan Avenue, Chicago 80, Illinois.

NONPAREIL
Turbine Oil

"Will outlast your turbine"

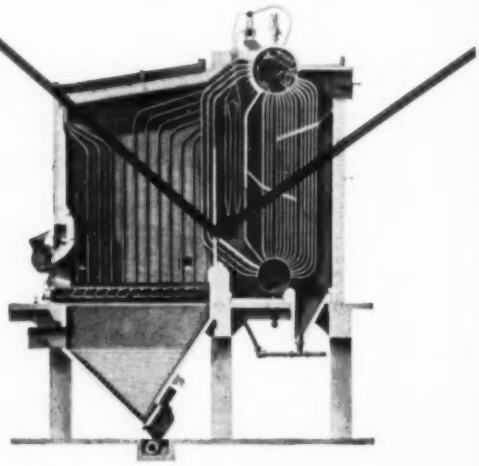
STANDARD OIL COMPANY (INDIANA) STANDARD

Which Vertical-Unit fits



Type VU-50
(for the higher capacity range)

This unit, the original VU design, may be fired by pulverized coal, oil or gas, or any combination of these fuels. Available for capacities up to 300,000, or more, lb of steam per hr, pressures up to 1000 psi and steam temperatures up to 900 F, or higher. Furnace bottom may be as shown or may be of hopper type. Economizer or air heater surface may be added.



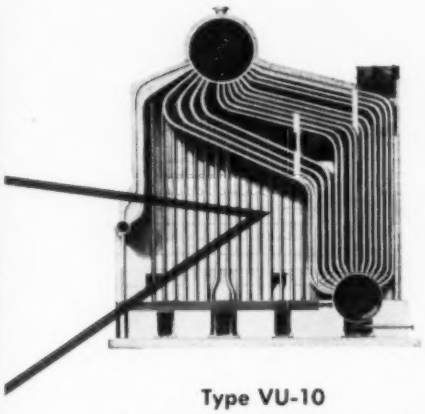
Type VU-30
(for the middle capacity range)

In this VU design, shown equipped with a C-E Spreader Stoker, the furnace proportions and arrangement of water wall surfaces may be adapted for firing by any type of mechanical stoker. Design is also adaptable for firing by oil or gas. Economizer or air heater surface may be added. Approximate capacity range 25,000 to 100,000, or more, lb per hr.

COMBUSTION ENGINEERING

ALL TYPES OF BOILERS, FURNACES, PULVERIZED FUEL SYSTEMS AND STOKERS; ALSO SUPERHEATERS, ECONOMIZERS AND AIR HEATERS

boiler your special needs?



Type VU-10
(for the lower capacity range)

This member of the VU family is designed for industrial load conditions and particularly for plants having small operating and maintenance forces. Capacities range from about 10,000 to 60,000 lb per hr. Firing may be by spreader, underfeed or chain grate stokers, or by oil or gas burners. Any of these methods may be substituted for any other, should fuel market conditions make this desirable.

VU-10? VU-30? VU-50?

No matter what your combination of operating conditions, one of these three units can meet the particular requirements of your plant exactly. *Capacity?* The Vertical-Unit Boiler covers a complete range of capacities, from 10,000 lb per hour for smaller plants, up to 300,000 or more pounds per hour for larger industrial plants and utilities. *Pressures? Temperatures?* VU Units are available for steam pressures up to 1000 psi and temperatures up to 900 F, or more.

Or perhaps your *fuel requirements* are unusual. The VU-50 may be fired by pulverized coal, oil or gas, or any combination of these fuels. In the medium and lower capacity ranges the firing may be by any type of mechanical stoker as well as oil or gas. Moreover, any one of these methods may be substituted for another should a change in the fuel market occur.

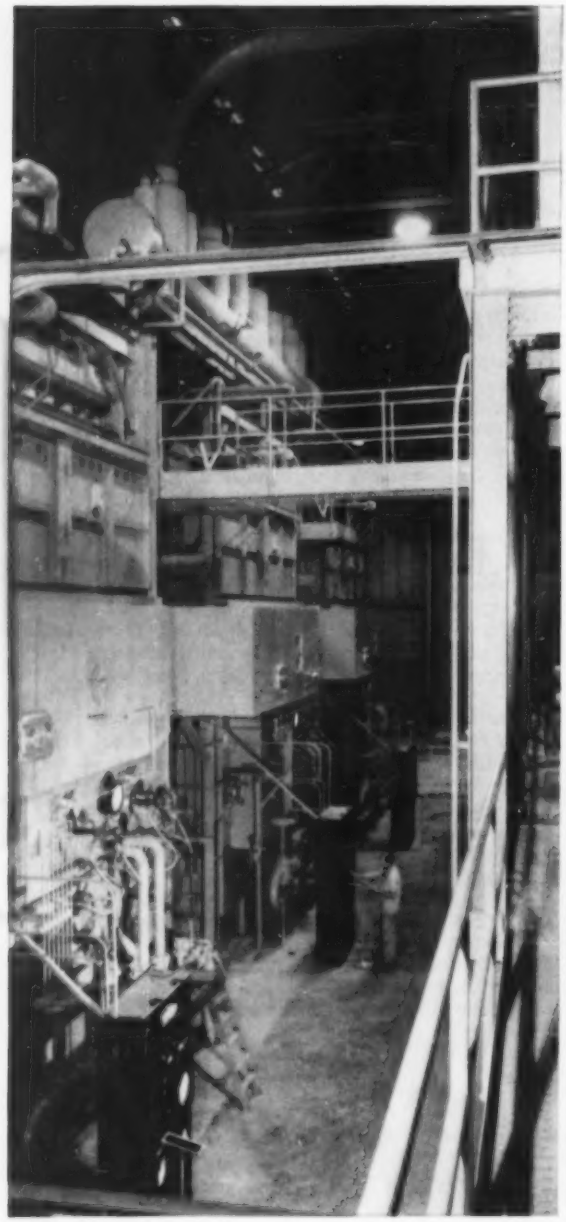
This flexibility . . . this ability to meet the widely varying requirements of plants in virtually every branch of industry — at efficiencies ranging up to 88% — accounts for the wide acceptance of the Vertical-Unit Boiler. Throughout the United States and Canada, Latin America and abroad, the VU has been selected for installations with an aggregate capacity of well over 100,000,000 lb of steam per hour.

Whether you are considering the purchase of equipment for replacement or expansion, or for a new plant, a C-E Vertical-Unit Boiler will provide the right answer to your particular situation. We shall be pleased to supply catalogs and any additional information upon request.

B-392

— SUPERHEATER, INC.
200 MADISON AVENUE, NEW YORK 16, N. Y.

COMBUSTION CONTROL



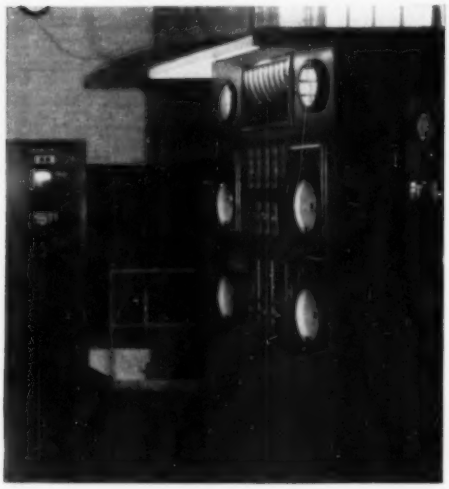
FOR
ALL SIZES OF BOILERS
ALL TYPES OF FIRING
ALL LOAD CONDITIONS

An automatic combustion control system, as designed and built by Republic, will enable you to operate your boiler (or boilers) over a long period at test efficiencies regardless of variations in fuel, load and other operating factors.

Republic combustion control is a unified system controlling simultaneously, in measured quantities and in correct proportions, the fuel and air input to the boiler.

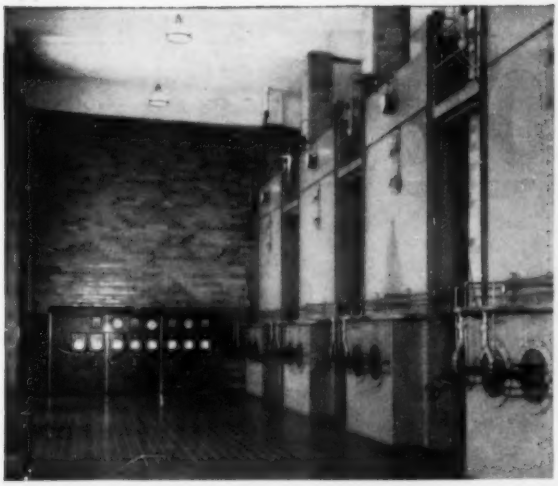
It automatically increases or decreases the fuel and air supply to the boiler in the correct amount to maintain constant steam pressure and in the correct ratio to maintain maximum combustion efficiency.

Republic automatic combustion control systems, either pneumatic or hydraulic, are available for all sizes of boilers, all types of fuel firing, and load conditions and any arrangement of draft equipment. They are completely described in Data Book No. S-21—write for your copy.

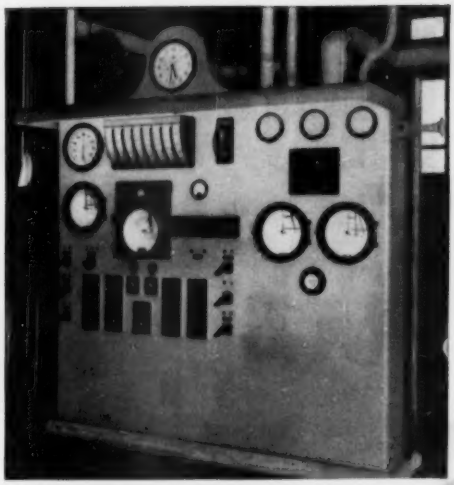


GAS FIRED—In this modern industrial plant steam is generated at the rate of 400,000 lbs. per hr. by four gas fired boilers operated by a Republic automatic combustion control system.

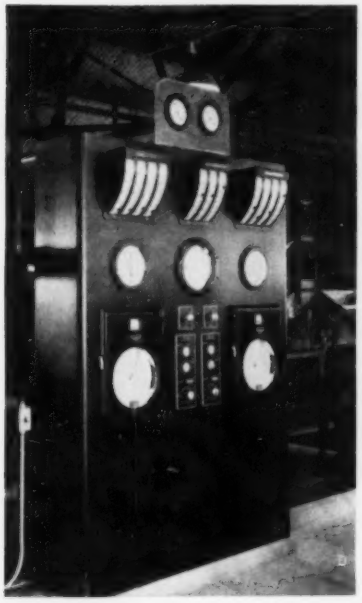
STOKER FIRED—The Republic instrument and combustion control panel for an 80,000 lbs. per hr., stoker fired boiler in a municipal power plant.



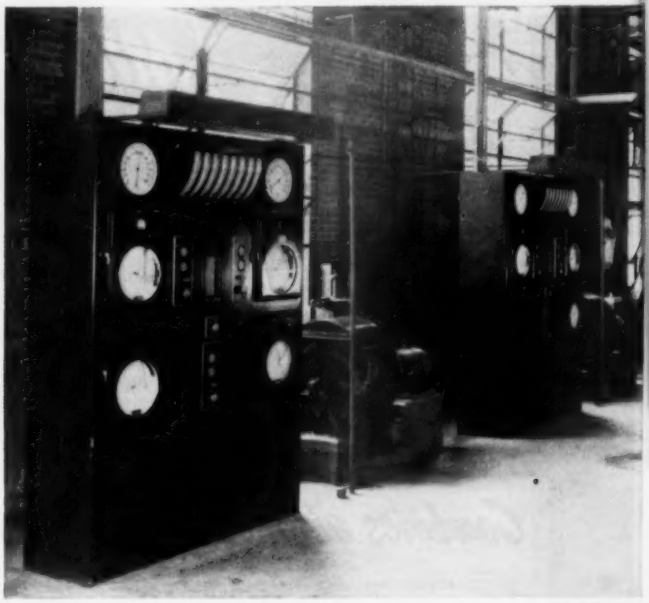
OIL AND GAS FIRED—In this model boiler room of a large institution the four combination oil and gas fired boilers are operated by a Republic automatic combustion control system.



STOKER FIRED—The Republic combustion control and instrument panel for the automatic operation of a 45,000 lbs. per hr. stoker fired boiler.



MIXED GAS—Republic instrument and control panel installed in a natural gasoline plant to automatically control two 50,000 lbs. per hr. boilers burning mixed gas.



STOKER FIRED—A typical Republic combustion control installation in the boiler room of a mid-western university for the automatic operation of two 25,000 lbs. per hr. stoker fired boilers. All boiler instruments and manual controls are centralized on the two panels pictured above.

REPUBLIC FLOW METERS CO.

2240 Diversey Parkway, Chicago 47, Illinois

NOW... One Grease applications in the

"The MILLION STROKE Industrial Grease"

A grease that will stand 100,000 punishing strokes of the ASTM Work Tester has been considered a superior lubricant.

In a deliberate attempt to break down Shell Alvania Grease, on the same tester, the run was extended 200,000 . . . 300,000 strokes . . . 500,000 strokes! Finally, at one million strokes the test was discontinued, because this grease would not break down—it was still a fit lubricant both in appearance and consistency.

Combines all these important advantages!

1. **Higher mechanical stability** than *any* conventional grease at operating temperatures.
2. **Pumpable at low temperatures**—even in unheated storage.
3. **Stable at high temperatures**—superior to the best "soda" greases.
4. **Impervious to water**—excellent resistance to washing out.
5. **Longer Service Life**—reduced consumption.

SHELL ALVANIA . . .

will service all grease majority of plants

SHELL ALVANIA GREASE

Shell Alvania is the one grease that will service all grease applications in most industrial or processing plants. It is already making important changes in maintenance and purchasing practice.

Because Shell Alvania, a patented grease, combines *all* of the advantages of the many special purpose industrial greases, this new lubricant does a highly efficient job in most any application you can name.

Gives you these plant savings:

1. **Extends TIME between greasings**—lasts longer . . . stays in bearings for much longer periods.
2. **Low-cost application**—fewer servicings per year and *only the one grease to handle at any time.*
3. **Simple inventory**—Shell Alvania Grease replaces up to 20 brands formerly required.
4. **Greater safety**—less chance of applying the wrong grease to expensive machinery.
5. **Better protection**—against heat, cold and moisture.

SHELL OIL COMPANY

50 WEST 50TH STREET, NEW YORK 20, N. Y.
100 BUSH STREET, SAN FRANCISCO 6, CALIFORNIA

SHELL

The "MILLION STROKE" Grease

Pair of Aces —BACK TO BACK!

ALLIS-CHALMERS BOILER FEED PUMP

The barrel pump, below, is one of three types we build for boiler feed service. The various features of this pump have been exhaustively tested and proved satisfactory for highest pressure requirements.

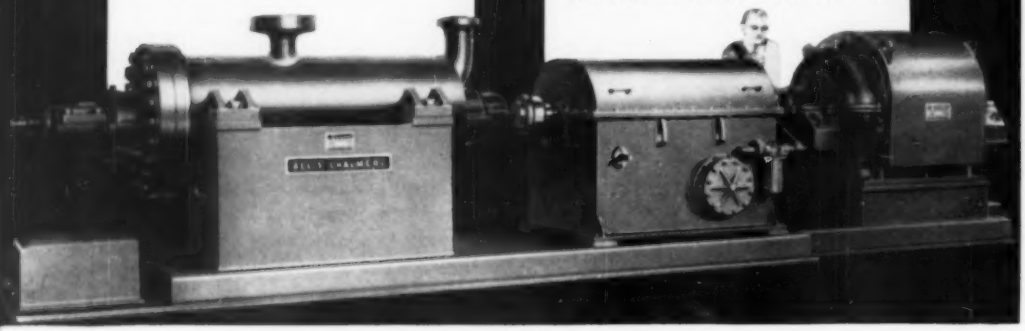
▶Back-to-back arrangement of stages and double volutes assure good axial and radial balance for high heads per stage. ▶Split inner casing simplifies maintenance. ▶Main horizontal joint of inner casing uses full hydraulic discharge to keep joint in compression. ▶Special design reduces possibility of flashing. ▶Uniform metal section thickness throughout volute casing equalizes expansion.

A-C 2-POLE MOTOR & CONTROL

The main thing you pay for and want in a boiler-feed pump drive is *reliability* . . . continuity of service with minimum time-out!

Here is how you get it in Allis-Chalmers two-pole motors: ▶Extra insulation protection built into the stator winding. ▶Improved bearing design eliminates oil leakage. ▶Bracket (housing) bearing construction results in easier mounting and alignment, greater rigidity. ▶Special, non-embrittling copper used in rotor rods. Rods silver brazed to end rings.

Available for indoor or outdoor application — drip-proof or splash-proof; water-cooled; tube-type totally-enclosed fan-cooled; or pipe-ventilated with matching Allis-Chalmers control.



HERE'S A COMBINATION that's hard to beat . . . a quality boiler feed pump, reliable 2-pole motor, and control — all Allis-Chalmers-*built* and *backed!*

CHOICE OF 3 TYPES OF PUMPS

At the pump end, depending on the head, capacity and pressure conditions you are figuring, you can select from 3 different designs:

- the new barrel-type, for larger steam stations operating against the higher pressures, 1200 to 2500 lbs; 300 to 2000 gpm.
- the "Doubleton", for pressures between 1200 and 1800 p.s.i.
- or the standard Type "M", for pressures usually under 1200 p.s.i.

READ WHAT USERS SAY

Regardless of which type of pump you finally select, it will keep your maintenance costs down to a rock-bottom figure. Here's what power plant people, themselves, say.

After 45,000 hours, "No measureable wear on shaft sleeves, rings or internal parts." 1250 p.s.i., 735 gpm pumps at an Eastern utility.

After 82,000 hours, "Not .001 in. wear on any internal part." 6 x 4, 5-stage pumps at Midwest utility.

"Only .002 in. wear on rings" after 8 years operation on pumps installed in 1937. On the strength of this performance, this Ohio utility re-ordered three 1800 p.s.i. pumps.

And on three, 800 hp, two-pole motors driving boiler feed pumps in a Midwest utility, "In over 20 years of uninterrupted service we've had to order replacement parts twice at a total cost less than $12 a year!"

GET AN ALLIS-CHALMERS "PUMPING PACKAGE"

If you want this kind of performance in your power plant, get in touch with an A-C pump application engineer today.

He'll show you how a complete Allis-Chalmers "Pumping Package" . . . pump, motor and control . . . can keep you time, trouble and money ahead in the long haul.

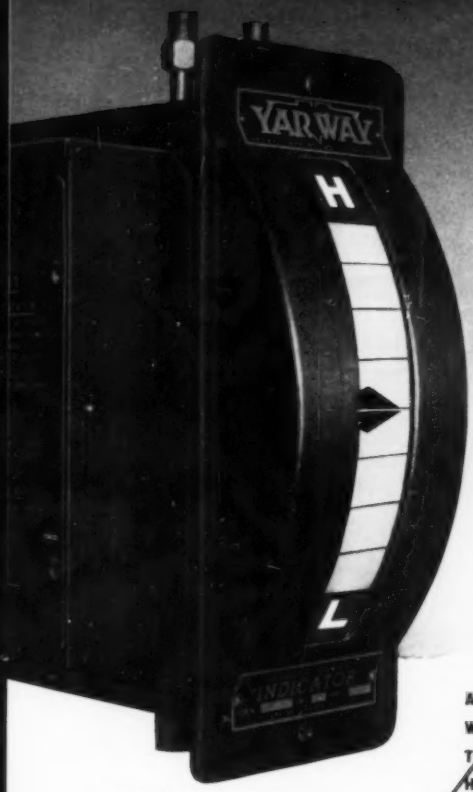
A-2998

ALLIS-CHALMERS, 953A SO. 70 ST.
MILWAUKEE, WIS.

ALLIS-CHALMERS

A COMPLETE SYSTEM...

FOR INSTANT, ACCURATE CHECK ON WATER
OR BOILER WATER LEVELS THROUGHOUT THE PLANT



Yarway Remote Liquid Level Indicator with Control Unit attached

Now you can have constant check-up on water levels wherever —and whenever—you want.

The Yarway Liquid Level Indicator, equipped with Yarway Control Unit and auxiliary electric signalling devices, provides this check at two or more locations anywhere in the plant.

The Yarway Indicator is always accurate because it is operated by the liquid itself. Indicating mechanism is never under pressure. There are no stuffing boxes. Complete separation of indicating and actuating parts is achieved by permanent magnet transmission.

The Automatic Control Unit is attached directly to the Indicator and operates the remote signal alarms (light or horn) at any remote locations.

The Control Unit may also be used as a control for mechanical equipment such as motor-operated valves, pumps, etc.

FOR COMPLETE DESCRIPTION AND SPECIFICATIONS OF YARWAY REMOTE LIQUID LEVEL INDICATORS, WRITE FOR BULLETIN WG-1822.

YARNALL-WARING COMPANY
114 Mermaid Ave., Philadelphia 18, Pa.

NEW!
A RECORDING BOILER WATER LEVEL INDICATOR — THE YARWAY HI-LO-GRAPH. SEE BULLETIN WG-1830.

Yarway Remote Hi-Lo-Alarm Signal Horns.

Three Yarway Remote Hi-Lo-Alarm Signal Lights, showing low level, normal operation and high level. Each unit shows all levels.

YARWAY REMOTE LIQUID LEVEL INDICATOR

Read how this

DETROIT ROTOSTOKER

fulfilled these

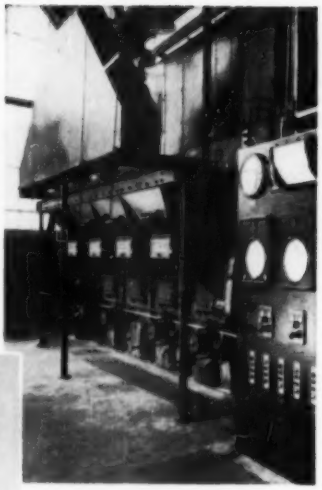
ECONOMY REQUIREMENTS

1. Continuous capacity.
2. Ability to handle wide range of coals.
3. High efficiency.
4. Ability to handle fluctuating loads.
5. Minimum labor.
6. Compact arrangement.

Modern Boiler Unit Serves Hanes Dye and Finishing Company Winston-Salem, N. C.

High efficiency Single Unit Boiler handles wide load swings, provides increased capacity, and saves 20% in fuel in a North Carolina plant.

By Ralph P. Hanes, President and W. O. Sprinkle, Plant Engineer



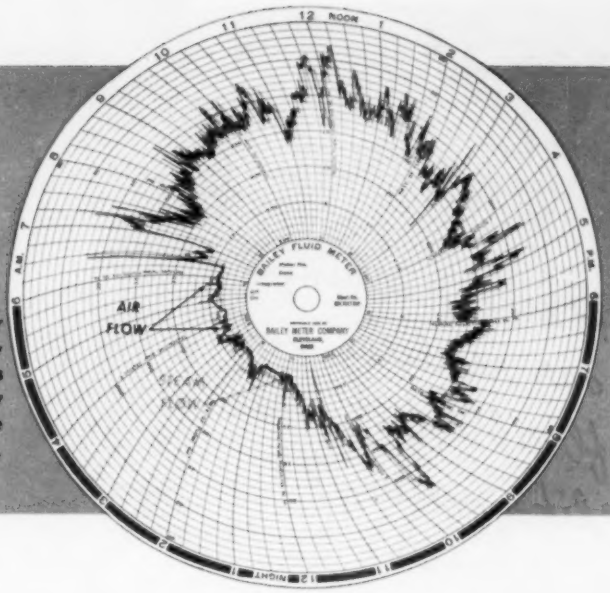
Detroit RotoStoker Power Dumping Type in the Hanes Dye and Finishing Company Boiler Plant.

Send for This Article

DETROIT SINCE 1898 STOKERS

Talk About Range

Typical 24 hour steam flow—air flow chart from Hanes plant. RotoStoker handles wide range of load fluctuations.



Hanes Dye & Finishing Co.
Winston-Salem, N. C.

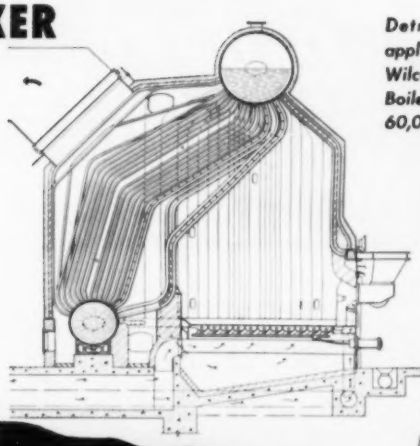
gets results with

DETROIT ROTOSTOKER

With a modern boiler Detroit RotoStoker accomplishes a three-fold saving: Fuel saving was 20%; steaming capacity was increased 20% to a 60,000 lb. per hour maximum; the new generating unit occupies 37% less space than four old boilers it replaced.

Detroit RotoStoker follows load fluctuations of 12 to 1, in a 24 hour period, interspersed with sudden swings over a wide range, with close automatic control of pressure as a routine operation.

The Detroit RotoStoker is a money saver. Write for copy of the Hanes Story.



Detroit RotoStoker—applied to Babcock and Wilcox Integral Furnace Boiler, capacity up to 60,000 pounds of steam.

Other Types and Sizes of DETROIT STOKERS for Every Industrial or Power Need

DETROIT STOKER COMPANY

GENERAL MOTORS BUILDING, DETROIT 2, MICHIGAN
District Offices in Principal Cities
Works at Monroe, Michigan

QUESTION:

What packings are resilient and flexible, but wear like metal?

ANSWER:

Garlock METAL FOIL Packings

COPPER GARLOCK 906—Pleated copper foil with asbestos core for steam, air or gases (except ammonia) and hot oils of low sulphur content, at temperatures up to 1000° F.

ALUMINUM GARLOCK 913—Pleated aluminum foil with asbestos core for hot oils at temperatures up to 1000° F.

LEAD GARLOCK 917—Pleated lead foil with asbestos core for steam, air, oil, water, ammonia or other gases at temperatures up to 550° F.

GARLOCK Metal Foil Packings are constructed of thin metal foil spirally wrapped around a fibrous center core. The durability of metal wearing surfaces in contact with the rod or shaft is thereby combined with the resiliency of a fibrous packing.

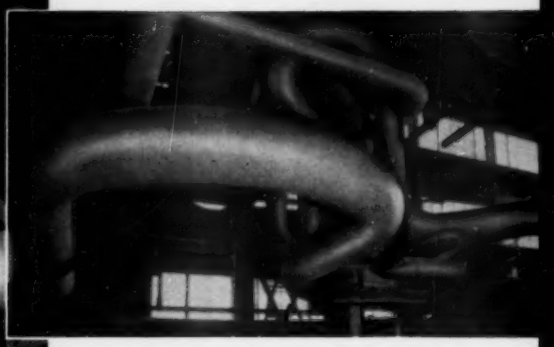
A patented, pleated foil construction used in several of these new Garlock packings imparts unusual flexibility to the packing and permits the forming of rings without undue distortion of the material. GARLOCK Metal Foil Packings are recommended for centrifugal or reciprocating pumps, compressors, engines, expansion joints, etc. Write for descriptive folder.

THE GARLOCK PACKING COMPANY
PALMYRA, NEW YORK

In Canada: The Garlock Packing Company of Canada Ltd., Montreal, Que.

GARLOCK

PACKINGS, GASKETS AND OIL SEALS

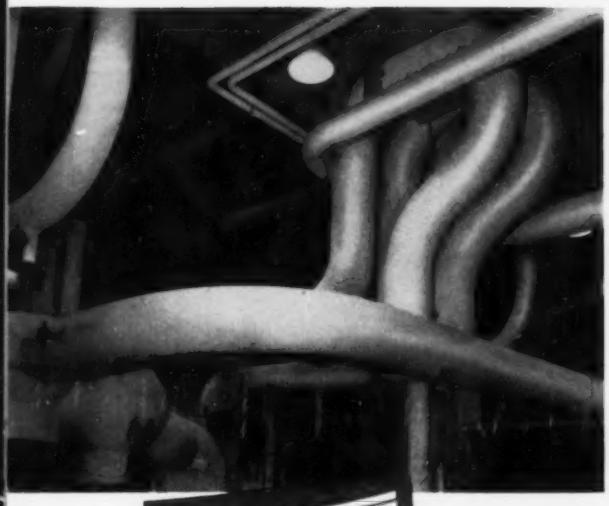


PIPING by MIDWEST

ANOTHER "First"

NEW SCHILLER STATION

First Complete Mercury-Unit Power Plant



The first installation of a mercury-unit power plant designed and built as a complete power generating unit . . . the Schiller Station of the Public Service Co. of New Hampshire at Portsmouth, N. H. is a notable achievement. When operating at designed rating of 40,000 kw and using Bunker C fuel oil, the heat rate is 9200 Btu per net kwhr.

The piping is by Midwest . . . fabricated and erected with undivided responsibility. "Firsts" are frequent with Midwest . . . have been throughout our more than four decades of experience with piping of all kinds. Midwest has grown up with modern high pressure and high temperature piping . . . through the years has achieved a wide reputation for better piping.

Whether you want a simple pipe bend, a series of complex prefabricated subassemblies, or a difficult piping job completely erected, Midwest has the facilities, the experience and the organization to meet every requirement. You will find it to your advantage to call upon Midwest whenever you need piping.

MIDWEST PIPING & SUPPLY CO., Inc.

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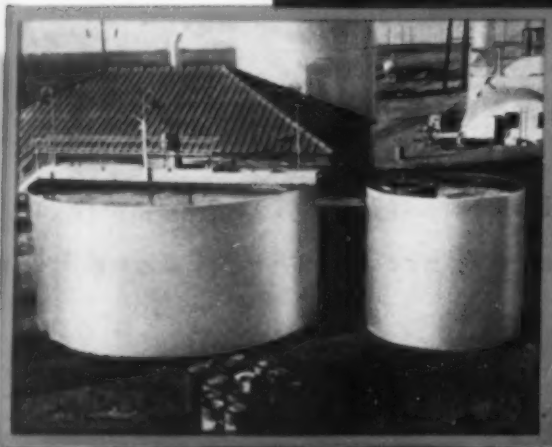
4 Plants are Better Than 1

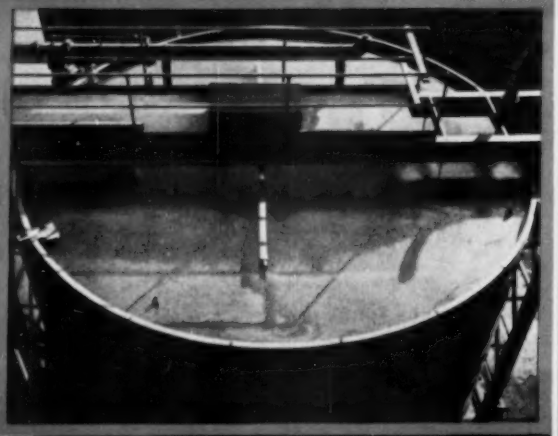
PIPING FABRICATORS AND CONTRACTORS

COCHRA

COCHRANE CORPORATION 87 YEARS OF SERVICE 1863 - 1950

ECONOMICAL REMOVAL OF IMPURITIES FROM INDUSTRIAL WATER SUPPLIES—TURBIDITY, COLOR, HARDNESS—REMOVAL OF SUSPENDED SOLIDS FROM WASTE





COCHRANE'S recognized authority in the field of water conditioning is exemplified in the relatively new field of water clarification by flocculation, in the improved Cochrane Sludge Contact Reactor. This equipment is meeting with pronounced success wherever it has been installed.

The Cochrane Sludge Contact Reactor is distinguished by the fact that the sludge bed is always in suspension, so that the sludge is always present when chemicals and water react.

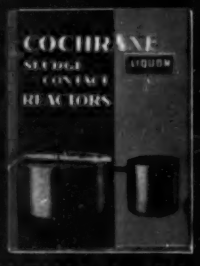
This is important, in that the precipitates or sludge must not be allowed to settle out on the floor of the tank if maximum clarification or softening is to be obtained. The water as it rises through the sludge bed is both treated and filtered.

Cochrane Sludge Contact Reactors are applicable to

1. Municipal and industrial plants for coagulation and/or softening, removal of turbidity, color, hardness, taste and odor
2. Boiler plants for silica removal
3. Fluoride removal, de-alkalization, iron and manganese removal
4. Paper, textile and other plants for process water—recovery of fibre stock and filler from white water

NEW PUBLICATION AVAILABLE

A new bulletin describing the Cochrane Sludge Contact Reactor, and illustrating different applications is just off the press. A copy will be sent on request.



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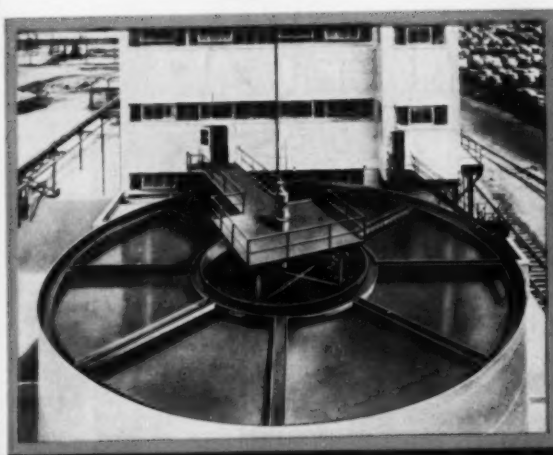
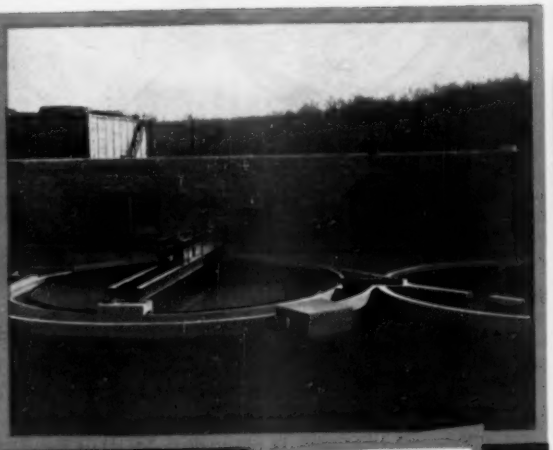
ANE ·Sludge· Contact REACTORS





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2701 Cresmont Ave. (11)
Telephone: Hopkins 7774-7775

BOSTON, MASS.
Cochrane Steam Specialty Co
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Telephone: HA 6-6447
(6-6416, 6-6448, 6-6449)

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Neil H. Brown
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Telephone: 3-7475

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309 West Jackson Blvd. (6)
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Telephone: Elmhurst 3140

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Telephone: Henderson 1500

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Stearns-Roger Mfg. Company
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Telephone: Acoma 2561

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INTERNAL OR EXTERNAL BOILER WATER TREATMENT?

FIGHTIN' WORDS? Well, not exactly . . . but certainly a frequent cause of dispute in the front office as well as in the boiler room! Which method is the most practical . . . the most efficient . . . the most economical?

There is no general rule that can be followed. Present-day practice says "External treatment is often desirable—but internal treatment is always necessary." However, every case is different and must be considered on its own merit. That's why so many engineers depend on the Drew System of Water Treatment for the correct answer.

The Drew System of Water Treatment eliminates guesswork! It starts with proper diagnosis. It includes recommendations for corrective treatment and other preventive measures such as modification of operating cycles and redesign of equipment, if required. It is specialized service applied to your individual boiler problem.

Don't gamble with guesses! Consult the Drew Engineer or write for further information.

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Power Chemicals Division

E. F. DREW & CO., INC.

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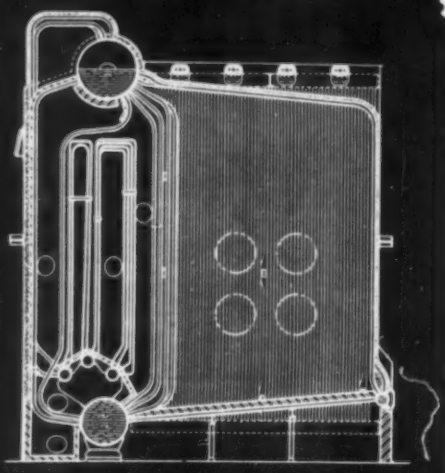
Nationwide service in Boiler Water and Cooling Water Conditioning

DREW PRODUCTS

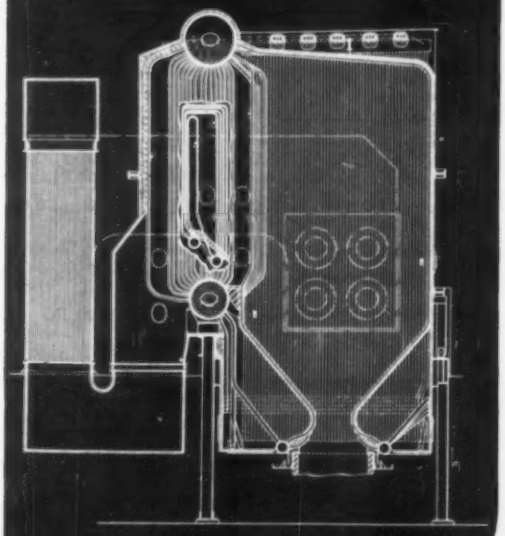
B&W INTEGRAL-FURNACE BOILER TYPE FH

Products of B&W Engineering for Economy



(Top) Flat-floor unit of 100,000 lb. per hr. steam capacity at 725 psi, and 650 F, fired with oil, gas, pulverized coal, and waste products of process plant.

(Bottom) Hopper bottom unit of 100,000 lb. per hr. steam capacity at 450 psi and 650 F, and coal-fired by B&W Pulverizers in a manufacturing plant.



bringing NEW *Economies in Steam* to all industries

Manufacturing, process, and service industries, along with many power companies all over the U. S. A. are finding the ideal answer to their new steam requirements in the B&W Integral-Furnace Boiler, Type FH. Installations range in steam capacity up to 350,000 lb. per hr. per unit, employing a wide diversity of fuels and firing methods, pressures to 1050 psi, and temperatures to 910 F.

An important advance in steam engineering, this B&W unit brings together, in a modern, standardized design, all the best features of the original and highly successful Integral-Furnace Boiler, introduced by B&W 17 years ago, plus many additional improvements . . . each one time-tested and performance-proved.

Immediate and widespread acceptance—over 39 million pounds per hr. of steam capacity installed or ordered—is evidence that the Type FH Boiler satisfies all modern requirements for dependability, efficiency, accessability, adaptability, and economy of installation and operation. It will pay you, as it has so many others, to consult B&W engineers about this boiler when planning steam plant expansion or modernization.

COST SAVING FEATURES OF B&W INTEGRAL-FURNACE BOILER, TYPE FH

HIGH AVAILABILITY, due to:
- Self-draining Superheater
- Continuous Ash Disposal
- Ease of Inspection
- Quick fuel changeover

HIGHLY DEPENDABLE, because of:
- Less Slagging
- Less Manual Cleaning
- Improved Soot Blowers
- Ease of Operation
- Improved Circulation: Clean, Dry Steam

HIGHLY ECONOMICAL, due to:
- Low Maintenance
- Minimum Space Requirements
- High Heat Absorption
- Fuel and Firing Flexibility

G-451

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Helping Industry Cut Steam Costs Since 1867

UP TO 50,000 MEGOHMS

with the New *Megger*® Insulation Tester

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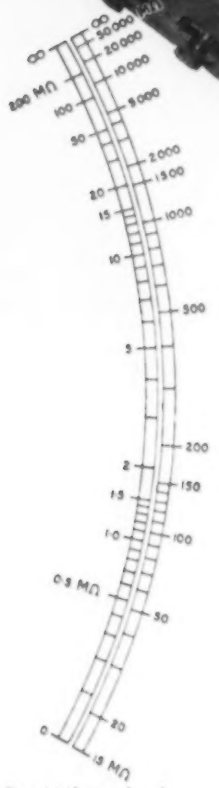
Improved Mechanical Features



Facsimile scale of 2,500-volt instrument

Never before has the direct-indicating cross-coil ohmmeter been capable of measuring such high values of insulation resistance!

This accomplishment comes at a time when more attention than ever is being focused by engineers on insulation resistance or d-c loss measurements as a practical non-destructive means of forestalling breakdown in electrical equipment.

These new sets also include several important improvements, such as static shielding, improved hand-drive mechanism, and a simplified design for motor-drive with better voltage stabilization.

The new line of MEGGER Insulation Testers is now available in the following ranges:

Volts	Inner Scale Megohms	Outer Scale Megohms
500 volts d-c	0 to 50	3 to 10,000
1,000 volts d-c	0 to 100	6 to 20,000
2,500 volts d-c	0 to 200	15 to 50,000

For unusual requirements, a special 5,000-volt instrument is available with range up to 100,000 megohms.

For description and prices, *write for Bulletin 21-20 PG*

JAMES G. BIDDLE CO.
Electrical & Scientific Instruments
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Megger® INSULATION TESTERS • GROUND TESTERS • OHMMETERS

A NEW IMO PUMP
AT LOWER COST THAN EVER BEFORE!

ONLY AN IMO GIVES YOU THESE ADVANTAGES

RELIABILITY — only three moving parts — no gears, vanes, pistons. Nothing to get out of order or adjust. The mechanical packing seals never require attention.

QUIETNESS — no noise, no vibration.

FREEDOM FROM PULSATION — continuous, axial flow.

HIGH SPEED OPERATION — for direct connection to motors, turbines, and machines. Also can be driven by belt or chain.

LOWER COST THAN EVER BEFORE

The new IMO A313A possesses all the unique advantages of the IMO pumping principle — it is built to the highest quality standards but it is designed especially to permit low cost, standardized quantity production.

The IMO A313A can be used for delivering up to 80 gpm against pressures to 150 psi, as required for lubrication service, oil transfer, low pressure, hydraulic systems, and general pumping of oil and viscous fluids.

Send for Catalog I-159-G

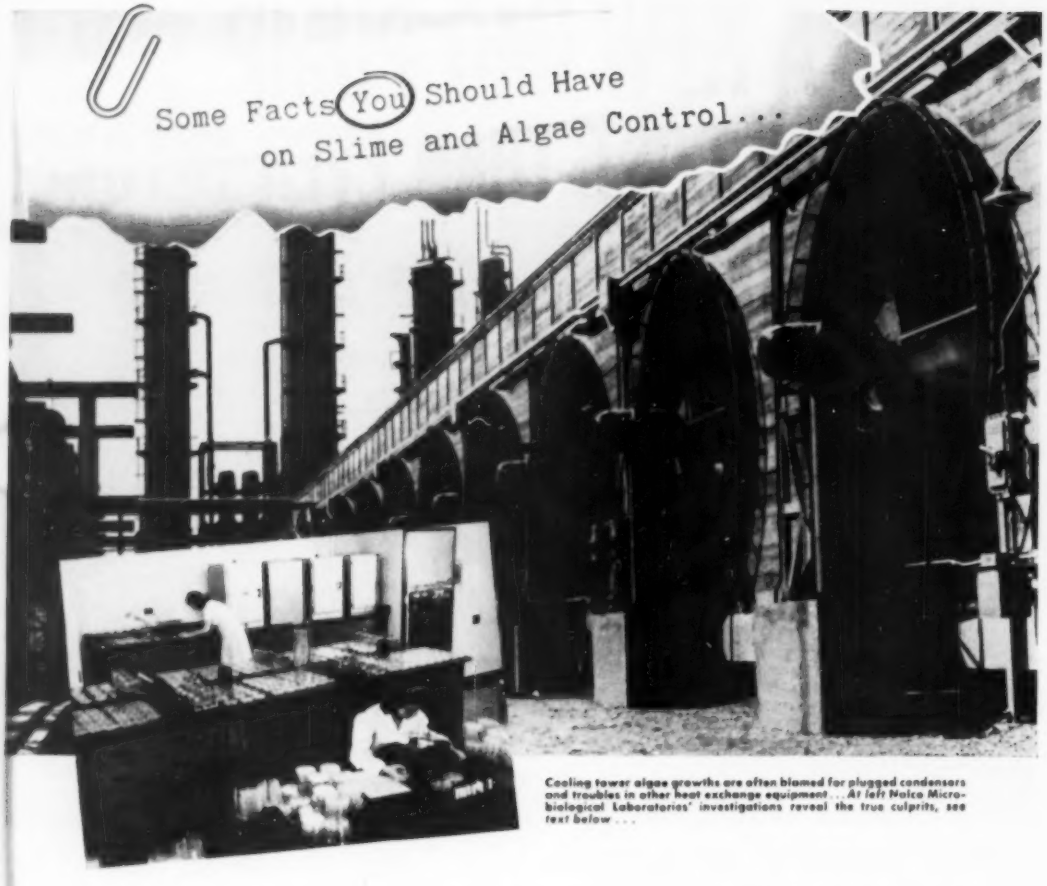
DE LAVAL

IMO-DE LAVAL PRODUCTS DIVISION

DE LAVAL STEAM TURBINE CO. • TRENTON 2, N. J.

I-159

Some Facts You Should Have on Slime and Algae Control...



Cooling tower algae growths are often blamed for plugged condensers and troubles in other heat exchange equipment... *At left* Nalco Microbiological Laboratories' investigations reveal the true culprits, see *text below* ...

ALGAE, the trouble-makers in cooling towers, seldom cause plugging, corrosion or iron oxide deposits in other parts of cooling systems . . . Nor can mold growths, slime-forming, sulfate-reducing and iron-depositing bacteria that do cause these internal difficulties be controlled with most algae-killing chemicals.

These established facts make it obvious that proper control of microbiological growths in any cooling system is first a job for experts. Proper identification, selection of treatment chemicals and dosages, and proper points of application will be handled efficiently and economically in your plant by Nalco Field Representatives, working closely with the Nalco Laboratories. Once proper microbiological control is established, consistent supervision to check effectiveness of treatment is all that is necessary to insure clean, slime- and algae-free equipment throughout your cooling system.

Your copy of Nalco Reprint No. 6, "A Practical Approach to the Problem of Cooling-Water Slime," will be sent promptly upon request . . . If your slime and algae control problem requires corrective action, now, write or call for a Nalco Field Representative.

FORMULA FOR SUCCESSFUL SLIME AND ALGAE CONTROL

- Identify slime-forming organisms to be controlled.

  A NALCO SERVICE

- Determine the best types of treatment to be used.

  A NALCO SERVICE

- Determine, by detailed survey, the proper method of application.

  A NALCO SERVICE

- Provide consistent supervision to check application and effectiveness of treatment.

  A NALCO SERVICE

NATIONAL ALUMINATE CORPORATION
6224 West 66th Place • Chicago 38, Illinois
Canadian inquiries should be addressed to Alchem Limited, Burlington, Ontario, Canada

THE *Nalco* **SYSTEM • Serving Industry through Practical Applied Science**

HELPFUL BULLETINS

Answers to many operating and maintenance problems will be found in these new bulletins and catalogs. List paragraph numbers of those you want on coupon below, detach and mail

ELECTRICAL

101 **Distribution Transformer**—Manufacturer's ACP distribution transformer, self-protected to reduce outages and operating expenses, is described in 8-pp Bulletin 61B7208A. Mechanical data and the five type designations of the transformer are given, along with a typical load-time curve for one of the units. The transformers are available in ratings of 3 kva through 100 kva—2400 to 14,400 v. Illustrated with photos, sketches. Allis-Chalmers Mfg. Co.

102 **Low-Speed Synchronous Motors**—Publication GEA-5332, 8 pp, illustrates typical installations of efficient high-power factor, constant-speed drives, describes their construction features, and indicates mechanical modifications and performance data. Covers three-phase and two-phase motors in company's "800" series with frame sizes of 6184 and larger and ratings from 20 to 15,000 hp. Photos show detail of stator and rotor design. General Electric Co.

103 **Splicing Kits**—Bulletin J30 presents company's packaged splicing kits for cable joints, both single and double connector types. Describes and illustrates jointing materials provided, tabulates use of jointing materials and includes instructions for ordering kits. Also provides ordering data on outdoor and indoor terminating kits and telephone cable joints. G & W Electric Specialty Co.

104 **Improved Voltage Regulators**—The unit-type construction, low maintenance quick-break tap-changing, automatic control and other advantages of company's new transformer-type ⅝ per cent step feeder voltage regulators are illustrated and discussed in detail in 16-pp Bulletin 01B6036C. Generously illustrated with photos and drawings, it provides full operational and engineering data on the regulators. Allis-Chalmers Mfg. Co.

105 **Motor Control**—A handy reference book on modern motor controls, this is the newest edition of manufacturer's ordering catalog and comprises 76 pp of condensed information, dimensions and prices of the most popular items in company's line. Covers a-c manual and magnetic across-the-line switches; a-c reduced voltage starters, control relays and contactors; synchronous and high voltage starters; d-c control relays, contactors, starters; drum switches, a-c d-c rheostats, speed regulators; push buttons, limit switches, and accessories. Allen-Bradley Co.

106 **Oil Circuit Breakers**—Moderate capacity oil circuit breakers of quick-clearing, non-oil-throwing design for outdoor distribution service where reliable and safe operation is required without frequent adjustment or inspection are described in 4-pp Bulletin 71B6030C. Brief text covers construction and features of the circuit breakers and is accompanied by photos of parts. Includes ratings, general dimensions. Allis-Chalmers Mfg. Co.

107 **Oil Fuse Cutouts**—Bulletin CA56, 12 pp, describes company's line of oil fuse cutouts and discusses their advantages. Also covers outdoor and indoor oil fuse cutout boxes, and gives complete mechanical and electrical specifications for both individual and gang-operated cutouts. Includes full ordering data, prices. G & W Electric Specialty Co.

INSTRUMENTS AND CONTROLS

108 **Wired Television**—Illustrated Bulletin 1525, 16 pp, introduces company's Utiliscope, a camera and monitor type of equipment designed to enable an observer to see where he can't look. Some of the many applications for this wired television which are described and illustrated include viewing instrument readings at remote points, checking boiler water levels, watching coal flow in chutes, watching hazardous laboratory tests, checking furnace ignition. Also shows the use of several sets in scheduling of assembly work. Diamond Power Specialty Corp.

109 **Meters and Control Systems**—Bulletin 13-G, 12 pp, explains engineering services company offers power engineers to help improve plant performance. Also describes and illustrates meters and control systems for power plants and industrial processes, including control for boilers, combustion control, feed water control, steam temperature control, pressure reducing control. Bailey Meter Co.

110 **Instrument and Control Panels**—Bulletin 773, 8 pp, explains how company's panels are made and where they are used. All operations of fabrication are discussed and illustrated—layout, cutting, drilling, welding, fitting, painting, wiring. Particular features like electric clocks, pressure gages, transformers, name plates, push-button stations and signal lights are discussed. Also includes many photos of panel installations covering all sizes, shapes and designs. The Hays Corp.

111 **Plant Wide Flow Measurement**—Catalog 83, 12 pp, describes and illustrates meters for permitting plant-wide flow measurement standardization at low cost. Explains use of three basic units in standard pipe sizes with indicating, controlling, recording or telemetering instruments. Includes specifications, dimensions and capacity data. Fischer & Porter Co.

112 **Laboratory Thermometers**—Chemical thermometers, low temperature thermometers, laboratory thermometer sets, calorimeter and differential thermometers and special test thermometers for various applications are pictured and described in Bulletin C, 24 pp. Gives specifications, ranges and sizes and explains use of instruments. Also includes nomograph for emergent stem correction and conversion tables. Precision Thermometer & Instrument Co.

113 **Thermometers**—Catalog 12, 8 pp, provides complete specifications for 89 different thermometers for a wide variety of temperature measurements including such applications as cooking vat, refrigeration line, steam, hot oil, air duct, diesel engine and general testing. Completely illustrated and includes price list. H-B Instrument Co.

114 **Laboratory Microscopes**—Catalog D-185, 24 pp, describes and illustrates many types of laboratory microscopes, discussing features and construction of the entire line. Provides photos and specifications for several models, including both monocular and binocular

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types, as well as accessory equipment. Lists prices and quotes terms of sales, ordering procedure. Bausch & Lomb Optical Co.

WATER TREATMENT

115 **Steam Jet Deaerator**—Bulletin W-218-B28, 8 pp, explains requirements for efficient deaeration and tells how company's steam jet models meet these requirements, discussing their operation and construction features. Illustrated with layout drawing, photos of typical installations and cutaway drawings of models for capacities under and over 200,000 lb per hr. Worthington Pump & Machinery Corp.

116 **Water Softeners**—Bulletin WC-108 is a 36-pp presentation of recent developments in hot-process water softeners. Explains boiler plant troubles caused by various impurities in water, outlines 12 methods of treating water to eliminate these impurities, describes reasons for the popularity of the hot-process method and its advantages, and explains the chemistry of hot-process water softening. The two basic designs and operation of company's hot process softeners are described, together with six adaptations of each design to various plant conditions, such as per cent make-up, treatment of condensate, deaeration. Methods of supplementary hot phosphate treatment are also discussed. Includes more than 30 diagrams of hot process designs and flow charts, together with photographs of installations. Also presents new chemical feeders, filters, and softener accessories. Graver Water Conditioning Co.

117 **Boiler Water Treatment Methods**—In illustrated File SM-3030, 16 pp, are discussed several methods of applying chemicals in the treatment of water for boilers. Covers pretreatment of raw water make-up, application of chemical feeding equipment to pretreating operations. Outlines methods of constant rate and flow responsive feeding to feedwater systems and direct to boiler drum, and discusses flushing periods, condensate returns and condenser water treatment, and chemical tanks. Proportioneers, Inc.

PIPING AND VALVES

118 **Pipe Joint Compound**—This is a small 6-pp folder on a pipe joint compound intended to expand as it sets. Tells how the compound is used and where, and discusses its economy, efficiency and other advantages. Gives specifications. Lists industrial users of the compound and describes briefly some of company's other products. X-Pando Corp.

119 **Pipe and Bolt Machines**—This 4-pp folder tells what users say about company's pipe tools. Includes comments on the use and qualifications of a power driven pipe machine representing many types of industries all over the world. Compiled to help engineers decide on pipe and bolt machines to serve their own needs. Beaver Pipe Tools, Inc.

120 **Valve-Sizing Charts**—Supplement 2 of Catalog 76 provides liquid and gas valve-sizing charts covering the ranges of 0.02 to 10,000 gpm and 1 to 100,000 lb per hr. The liquid valve-sizing chart takes into account the difference between pressure drop across the valve and across the valve ports alone, liquid viscosity and specific gravity in determining port areas and valve sizes. The gas chart takes into account inlet and outlet absolute pressures, gas specific gravity and temperature. Fischer & Porter Co.

121 **Safety Head Price List**—This is a 16 pp illustrated bulletin explaining sizes, specifications and prices of company's safety heads and accessories, including safety head rupture disc, flanges and vacuum supports, refrigerant relief valves, pressure-vacuum vent valves, and combined vent valve-flame arrestor units. Also gives examples on how to order various sizes of safety heads and accessories. Black, Sivalls & Bryson, Inc.

TURBINES, PUMPS, COMPRESSORS

122 **Mechanical Drive Turbine**—Bulletin 4215, 4 pp, contains a complete description and specifications of a single stage mechanical drive turbine for pressures to 1450 psig, initial temperatures to 850 F FT and back pressures to 300 psig, a turbine described as the first of its type to be designed especially for high pressure service. Cutaway illustrations show construction of turbine, labyrinth seals. The DeLaval Steam Turbine Co.

123 **Self-Priming Jet Pumps**—The advantages and applications for company's cycling jet pumps designed for handling any liquid and for operation by air, gas, or steam pressure, are presented in Bulletin 5020, 4 pp. Discusses pumps' design, simple operation, safety factors, and performance, and includes specification. Unit is illustrated by blueprint drawing and photo, and two installations are pictured. Penberthy Injector Co.

124 **Rotary Pumps**—The design and construction features, operation and maintenance of company's rotary pumps in 5 to 1500 gpm capacities are explained and illustrated in detail in 6-pp Bulletin 307. Also covers applications of the pumps and includes photos of various types and several installations. Blackmer Pump Co.

125 **Electric Driven Compressors**—Form 3130, 20 pp, introduces company's L design compressor, described as a heavy-duty, crosshead type, 100-psi, two-stage design in sizes from 125 to 350 hp. Fully illustrated in color with photos, cutaway drawings, the bulletin explains compressor's operating economy and compact design, showing how its packaged construction and simplified controls afford easy installation and operation. Construction and design features are described in detail with special emphasis on bearings, lubricating system, valves, intercooler and motor drive. Includes ratings, dimensional data, several photos of installations. Ingersoll-Rand Co.

BOILER ACCESSORIES

126 **Blowdown Systems**—This 4-pp folder and chart were prepared to show power engineers how to determine the proper size continuous blowdown system for an installation. The chart takes into consideration such variables as impurities in feed water, desired concentration in the boiler, amount and temperature of make-up and boiler pressure. Size of the required blowdown system is read directly from the chart. It shows annual fuel savings effected by blowdown heat exchangers based on average fuel cost and boiler efficiency. Corrections to specific costs can be made. Comments on advantages and disadvantages of various types of installations are also made. The Hennessy Co.

127 **Boiler Rejuvenation**—This 4-pp bulletin, titled, "New Life for Old Boilers," describes how old boilers can be rejuvenated at low cost, with necessary tube replacements and repairs and company's safety hand hole caps. Illustrates several installations. Kay Co.

128 **Boiler Tube Data**—Bulletin TB-331 provides 4 pp of technical data on electric resistance-welded steel boiler tubes. Tables are furnished on maximum allowable working pressures, conforming to ASME Specifications SA-178, for different diameters and gages of tubes for water-tube and fire-tube boilers. Another table determines weight in pounds per lineal foot of steel tubes in various minimum wall sizes. The Babcock & Wilcox Tube Co.

129 **Mechanical Tubing**—Bulletin TB-324, 4 pp, explains increased production, lower manufacturing costs and short cuts to improved design afforded by use of company's mechanical tubing. Discusses machining, forming and joining and lists types and steels available, sizes, surface finishes, shapes. The Babcock & Wilcox Tube Co.

(Continued on page 120)

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POWER ENGINEERING

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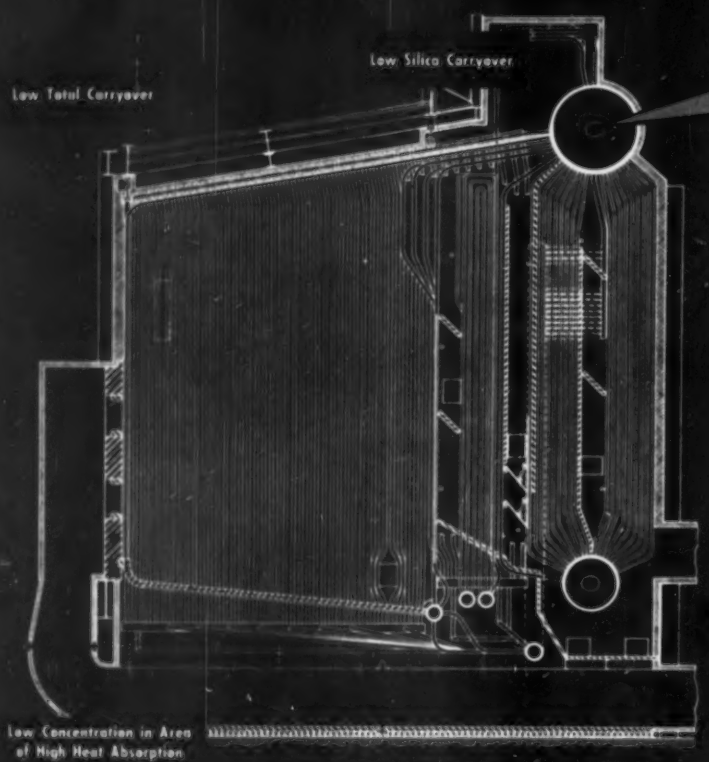
For New England: New England Coal & Coke Co., For Export: Castner, Curran & Bullitt Inc.

high steam purity where it counts

Foster Wheeler Dual Circulation



Three FW Units for THE TEXAS COMPANY
LAWRENCEVILLE REFINERY
LAWRENCEVILLE, ILLINOIS

Steam Capacity
300,000 lb per hr

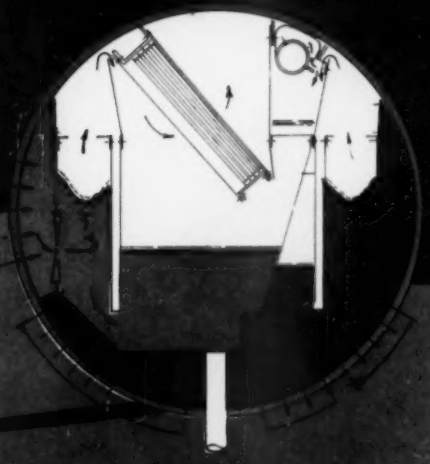
Superheat Control Range
150,000 to 300,000 lb per hr

Pressure Superheater Outlet
600 psi

Final Steam Temperature
750 F

Minimum Blowdown and Heat Loss

Steam Generators



Advantages for Both Central Station and Industrial Use

Under modern operating conditions of high pressure and temperature, the problem of steam purity is of increasing concern to the designers and operators of industrial and central station steam generators. Foster Wheeler engineers have successfully met this challenge by developing the Dual Circulation Steam Generator which already provides materially *higher availability, improved efficiency, and lower maintenance of high pressure steam turbines* at one large midwest refinery. Particularly in installations which have high makeup requirements, the Dual Circulation Steam Generator is capable of providing steam of higher purity with less blowdown than is possible in a conventional unit. In units operating on condensate, total solids and especially silica carryover are almost negligible with this design.

Design Features of Dual Circulation Steam Generator

The Foster Wheeler Dual Circulation Steam Generator consists of two separate heat absorbing sections each with its own independent circulating system. The feedwater goes to the primary, high duty, radiant heat absorbing section, which is continuously blown down into the low duty secondary convection section. Most of the steam is generated in the primary section where silica and boiler water concentrations are low. Thus, a marked reduction in the amount of silica carryover in the steam to the prime mover is achieved and tube damage is held at a minimum.

The Texas Company Orders Three Units for Lawrenceville Refinery

Because of adverse water conditions at the Lawrenceville Refinery, The Texas Company ordered three units, designed for high makeup with high concentration in its makeup. The Lawrenceville project is part of the present construction program in which all crude units are being engineered and constructed by Foster Wheeler.

For further information, write:

FOSTER WHEELER CORPORATION, 165 BROADWAY, NEW YORK 6, NEW YORK

FOSTER WHEELER

How BAILEY CONTROLS Save Money

FUEL

1. Average saving as reported by users is 5%.
2. Waste fuel automatically used when available by Multi-Fuel firing.
3. Flexibility of control simplifies switching to most economical fuel.

MAINTENANCE

1. Furnace wall repairs reduced by limiting maximum furnace temperature through close control of excess air.
2. Slagging of heating surfaces reduced to a minimum by accurate control of excess air.
3. Feed water pumps protected at low ratings by automatic by-pass control.
4. Possible damage to turbine from water carry-over avoided by feed water control.
5. Damage from excessive steam temperature avoided by proper control of excess air and superheat.
6. Burning of tubes insured against by proper control of feed water and excess air.

AUXILIARIES

Power required by fans is less since control continuously operates on minimum allowable excess air.

Power for feed pumps may be reduced through control of excess pressure by pump speed.

STEAM USE

1. Maintains Prime Mover efficiency by supplying steam at design pressure and temperature.
2. Improves process operation by controlling flow, pressure and temperature.

APPLICATION TO YOUR PLANT

It is worth your while to consider these modern methods for your plant—for money-saving, for greater safety and for improved power service. Call on your local Bailey Engineer to analyze your lay-out and make recommendations; or write for Bulletin 15-C giving further details on Bailey Meters and Controls. Bailey Meter Company, 1040 Ivanhoe Road, Cleveland 10, Ohio. In Canada—Bailey Meter Company Limited, Montreal. A-92A

BAILEY METER COMPANY

1040 IVANHOE ROAD · · · CLEVELAND 10, OHIO

COMBUSTION • PRESSURE
FEED WATER • LIQUID LEVEL
TEMPERATURE • FEED PUMPS

FOR

✔ *softening*

dealkalization

deionization

silica-removal

Monobed deionization

A complete line of
AMBERLITE
ion exchange resins

In a pamphlet that belongs under the glass on your desk top we've condensed a part of our knowledge on the use of AMBERLITE IR-120 in water softening. The extremely high capacity of the resin, even when operated at low regeneration levels, is described. The effects of flow rates and water temperatures on headloss and expansion are tabulated. And we've squeezed into 5 tables and 811 words a description of the resin that resists acid, alkali, chlorine, heat, attrition, and waters low in silica.

If you plan to install a new high-capacity softening unit or if you want to replace zeolites of low capacity with a resin of high capacity and efficiency, you owe it to your boilers to write Department PGI-2 for your copy of the pamphlet on AMBERLITE IR-120.

Send for this free folder today

CHEMICALS FOR INDUSTRY

ROHM & HAAS COMPANY

THE RESINOUS PRODUCTS DIVISION

Washington Square Philadelphia 5, Pa.

The Resinous Products Division was formerly The Resinous Products & Chemical Company

AMBERLITE is a trade-mark, Reg. U. S. Pat. Off., and in principal foreign countries.

NEW EQUIPMENT NEWS

WHAT'S NEW? On these pages the Editors summarize the outstanding industrial developments of leading manufacturers who will supply you, free of charge, the bulletins or other information desired. For ease in making requests use the no-obligation, postage-paid card pages 35-36.

1—FEEDWATER TREATMENT

Is potassium type, developed for Diesel steam generators

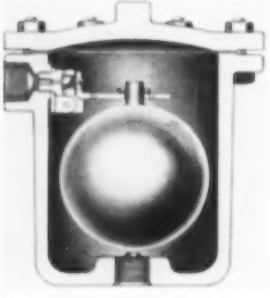
Formula 353 is a powdered treatment described as rapidly and completely soluble. Tests are said to show that it quickly neutralizes dissolved oxygen, reducing corrosion of outer coils and increasing their service life. Fluidity of sludge is improved, company adds, and this serves to coagulate mud and sludge reaching steam separator and increase the rate at which suspended solids settle in the water storage tanks. The amount of sludge recirculated through the generator is therefore said to be reduced, with subsequent reduction of interference with controls and strainers.

It is also pointed out that with Formula 353 silica is converted to soluble form or removed. This formula is intended for direct application to water storage tanks, automatically by chemical feeders, or solution tanks and proportioning pumps on the units. Dearborn Chemical Co.

2—VENT AND DRAIN VALVE

Has simplified ball-type seating mechanism, operates automatically

This valve is easily installed in water or oil piping systems to remove entrapped air, company states, or in compressed air systems to remove water and oil. The cycle of filling and emptying keeps repeating with each accumulation.



Sizes are available to take care of air requirements up to 150 psi and water up to 125 psi. Body and cap of valve are cast iron and the float is copper. The ball seat is Exelloy and the ball is stainless steel. Crane Co.

3—FAULT LOCATOR

For finding faults on lead covered cables installed in ducts

This is a high-voltage d-c impulse transmitter with pick-up coil and pointer indicating detector. Besides its primary purpose, it is said to have applications on aerial and buried cable

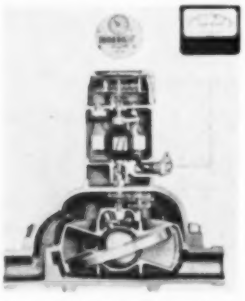
and in utility and industrial service.

In operation the set is essentially independent of the type of fault or its apparent resistance, company points out, and it depends only on the impulse voltage required to break down the fault. The Model 2-2 is rated up to 20 kv with a discharge capacitance of 2.5 muf, for use on cable up to 15 kv and higher. It requires 500 w to operate from a 115-v source of high voltage d-c for proof testing on all type of electrical equipment. Similar sets of higher and lower kv and muf can be supplied. James G. Biddle Co.

4—METER AND CONTROL

For indicating and regulating rate of flow of corrosive liquids

The Veriflow Meter is designed to measure flow of almost any fluid, indicating rate at all times, and totaling every gallon on its register. Its measurement is volumetric, each complete movement of measuring piston displacing a fixed volume of liquid, which enters inlet port and fills space above and below piston. Volume flowing in annular space around center ball of piston causes it to move with a "nutating" motion until liquid discharges



through outlet port. The rate of flow indicator (which can be mounted remotely) measures output of the generator and is calibrated to indicate corresponding rate of liquid flow through meter.

The Veritrol is a Veriflow Meter plus automatic control equipment. Its use involves the setting of a knob at the flow rate desired. The output of its meter generator is measured by a contact-making relay which operates a motor which, in turn, positions a control valve. This valve controls rate of liquid flow through meter until generator output balances a potentiometer circuit at rate of flow for which it is manually set. The Hays Corp.

5—HEAT EXCHANGERS

Feature all-cuprous, removable tube bundle construction

According to manufacturer, the Type BCP Exchangers are available in a broad range of sizes which compare favorably in cost with many units of other construction and materials and cost less in the smaller sizes. Originally designed for service on Navy combat vessels, these exchangers have been redesigned to adapt them to low-cost quantity production and to provide larger transfer surface. Ross Heater & Mfg. Co., Inc.

6—TIMER ENCLOSURES

Are hermetically sealed for use in corrosive, high humidity atmospheres

Hermetic sealing of these enclosures is intended to give maximum protection against fungus growth, salt spray, humidity, oil spray, sand, dust, explosive atmosphere and climatic changes. The enclosures are evacuated to 100 mu and filled to one atmosphere with dry nitrogen so full switch ratings can be used even at high altitudes where contact capacity is normally reduced, company states, and deterioration of motor brushes is eliminated. A. W. Haydon Co.

7—MOTOR STARTERS

Are a-c combination magnetic type with disconnect switches

These starters are for use where a magnetic full voltage starter coupled with disconnect means at starter location is preferred over separately mounted components. Starters are available with fusible or non-fusible disconnect switches. They feature front operation, simplified installation, thermal overload protection, high arc interruption capacity, provision for padlocking in on and off positions and interlock protection in on position, company states, adding that they are designed for maximum safety.

They come in four standard sizes to

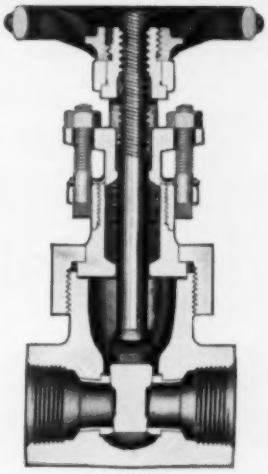
All the piping equipment you need ...on one order to CRANE

SMALL STEEL VALVES WITH BIG VALVE FEATURES

Crane 600-Pound Small Steel Gates with Union Bonnet—for steam, water, gas, or air—are smaller, lighter, and more compact than usual high pressure design . . . yet are amply strong. Metal sections at all points provide extra strength and safety under rough usage and extreme pressure-temperature conditions.

Body, bonnet and yoke are high quality carbon steel. Seating is Hardened Stainless to Exelloy, offering superior resistance to wear, corrosion, and temperature effects. Husky bonnet ring with long, precision-cut threads pulls up easily . . . always stays tight. Long-lived blowout-proof gasket in bonnet joint is unaffected by highest temperatures or fluids on recommended services. For more information, **write for circular AD-1741.**

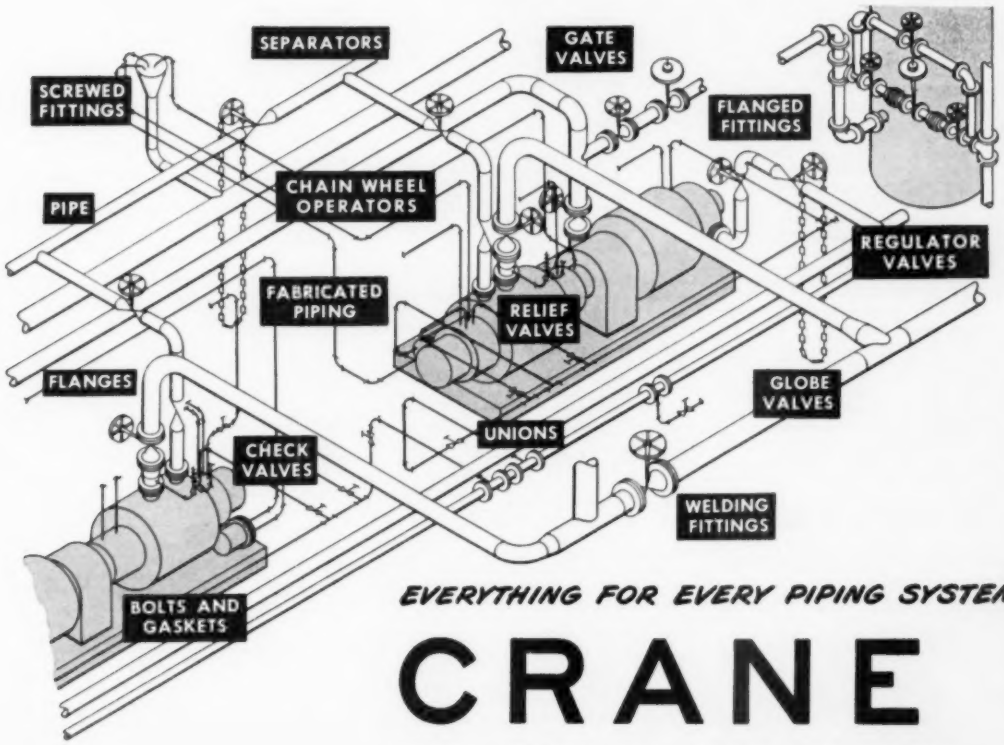
CRANE CO., 836 S. Michigan Ave., Chicago 5, Ill.
Branches and Wholesalers Serving All Industrial Areas



No. 3602XW

For steam up to 850 deg. F., and for water, gas, or air. Sizes: ¼ to 2 in. Screwed or welding ends

THIS POWER PLANT INSTALLATION, FOR EXAMPLE, CAN BE COMPLETELY EQUIPPED BY CRANE



EVERYTHING FOR EVERY PIPING SYSTEM

CRANE

VALVES • FITTINGS • PIPE • PLUMBING AND HEATING

50 hp, 3 ph, 550 v, 60 cycles maximum. Standard operating coils can be supplied for 110, 220, 440 and 550 v service on frequencies of 25, 50 or 60 cycles. Standard starters have manually reset overloads, but automatic reset overloads and other controls can be furnished. Ward Leonard Electric Co.

8—MAGNETIC LEVEL

For lining up pipe, leveling machinery, electrical equipment

The Stik-T-Metal Level is made with Alnico 5 magnets, company states, which have a holding power of 18 to 29 lb, keep their strength, and are not affected by heat or vibration. Magnetic keepers are furnished with the levels, to be used when level is put away in tool box to prevent other tools from clinging to it. Level is priced at $4.50. The Tunxis Mfg. Co.

9—HAND HOISTS

In ½ to 4 t capacities, offer light weight and close headroom

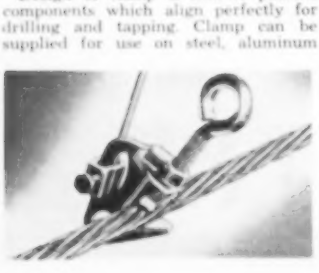
These Safety Hoists are described as compact and easy to handle in tight places. Their construction features simplicity of design, a modern gear drive, Weston type brake, steel load chain, steel housing, self-lubrication, and drop forged top and bottom hooks. Hoists are designed to provide a high safety factory against possible impact loadings. Wright Hoist Div., American Chain & Cable Co., Inc.

10—HOT LINE CLAMP

For copper and copperweld conductors, takes wide range of wires

The 408C Hot line Clamp is described as strong, while small and lightweight, and accommodates 4 0 strand to six solid line wire, and 3 No. 6 to eight solid tap. Clamp is made of cold forged, work-hardened copper. Eye screw, tap screw and pressure bar are silicon bronze and tap wire connector is a seamless high conductivity copper extrusion.

Design of clamp is said to provide components which align perfectly for drilling and tapping. Clamp can be supplied for use on steel, aluminum over steel, and copper. Reliable Electric Co.



11—ROLLING SCAFFOLD

Is sectional-type lightweight aluminum for overhead work

This scaffold is said to be easily erected and is offered in both a stairway and ladder type. All parts, except casters and platforms, are light, durable aluminum alloy, manufacturer points out, and the scaffolds are supplied in one or more sections, with guard rails. The bottom section, including non-elevating casters, is 7 ft 3 in. from ground to first platform. Each additional section is 6 ft 8 in. high. Base dimensions are 4 ft 6 in. by 6 ft.

Two types of 5 in. steel casters are available—a non-elevating type and an adjustable type with a steel screw providing extra height. Frames for intermediate sections slip over a sprocket in the lower section and this joint is secured by a hinged pin. Horizontal members are secured by a spring lock. The Patent Scaffolding Co., Inc.

12—PNEUMATIC CONTROLLER

For uses where electrical components are final controlled element

The Cono Model EB Pneumatic Current Controller can be used in control systems for the ultimate control of temperature, flow, speed, pH. Among their recommended uses are temperature control of electric furnaces and

drying ovens, and on electrically heated stills and columns in pilot plants and laboratories. Controller is also used in conjunction with a small rheostat-potentiometer for controlling input to electronic speed control devices.

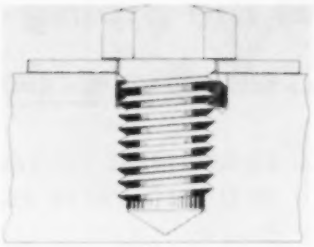
The controller utilizes a standard electrical component modified for continuous throttling control service, and company's pneumatic cylinder operator which includes an integrally mounted positioning device. Conoflow Corp.

13—LOCKING NUTS

For studs, bolts, other threaded parts in mechanical assemblies

Studlocs incorporate eliptical spring steel retainers. In use, the stud or bolt forces the retainer into circular shape, creating rigid locking pressure on the threads. The stud or bolt may be adjusted to any position, company points out, and will remain in position regardless of vibration. This retainer floats in a counterbore and carries no load. Tension or compression stress load is carried by threads in the tapped hole.

The stud or bolt can be applied repeatedly without distortion to retainer or bolt, it is claimed. Initial assembly



is described as simple and subsequent removals require no further adjustment. Studlocs are made in standard stud and bolt sizes from ⅜ to 2 in. in both NC and NF thread series. Special sizes can be engineered to suit requirements. Security Locknut Corp.

14—FLOW METERS

Are intended to provide plant-wide flow-measurement standardization

The Ratosleeve Meters are suitable for liquids, gases, pulps and slurries. Their three basic units in standard pipe tees plus indicating, controlling, recording or telemetering instruments are designed to provide complete plant-wide flow measurement. Flow rates from 2 to 6200 gpm and from 3 to 12,500 cfm are handled with a minium number of basic metering parts designed for installation inside standard pipe fittings. Mountings for indicators, controllers, recorders, integrators and telemetering instruments are interchangeable in all sizes. Fischer & Porter Co.

15—PRESSURE CONNECTORS

For copper, aluminum or steel wire in sizes 14 AWG to 500 MCM

To provide for permanent maximum pressure, the tightening bolt, guide nut and contact pad of the Wide Range Pressure Connectors are made of steel. Positive conductivity is said to be assured by the lug body being formed of hard-drawn electrolytic copper, also intended to resist corrosion cracking. Entire unit is cadmium plated.

Each connector can handle a wide range of wire and cable sizes. The three smaller sizes, NE 35, 60 and 100 can be installed with a screwdriver; larger sizes, NE 200 and 400, with a wrench. All sizes have minimum overall dimensions to expedite installation in small gutters. National Electric Products Corp.

Mark the numbers of the items you wish to receive on the no-obligation, no postage card. Pages 35-36.

The DIAMOND "UTILISCOPE"

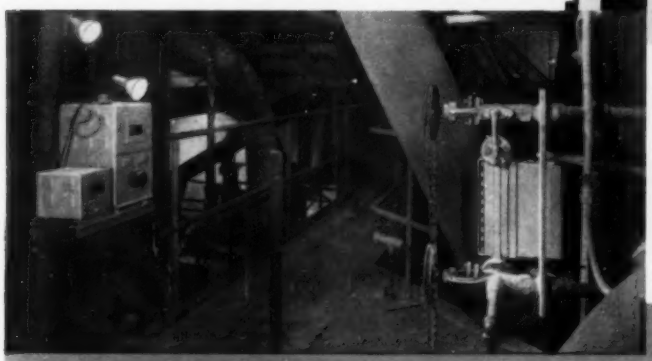
(WIRED TELEVISION)

Brings Boiler Water Level to the Control Panel

there can be no mistake

Regardless of the obstructions and the distance between boiler water level gauge and control panel, the Diamond "Utiliscope" brings an exact instantaneous and continuous picture of the water level to the operator in the control room. There can be no mistake because the "Utiliscope" shows either the correct reading or there is no image.

The continuous picture produced by 60 image fields per second (sound motion pictures have 48) shows *instantly* any change in water level . . . there is no measurable time lag. Among the other advantages of the "Utiliscope" are: sharp contrast, simplicity of design, rugged construction, easy installation, exceptional stability and simple control. It has numerous additional uses such as remote observation of stack discharge, combustion in furnaces, destructive testing, etc. Ask for Bulletin 1025 which will suggest many other applications.



(Above) The "Utiliscope" screen is readily incorporated into the control panel where it is most convenient and always before the operator.

(At left) The "Utiliscope" camera is permanently focused upon the boiler water gauge. It sees and instantly transmits every variation in water level . . . its attention never wanders.

The "Utiliscope" is a product of the Capehart-Farnsworth Corporation and the Diamond Power Specialty Corp.

"Utiliscope"—Registered U.S. Patent Office

DIAMOND POWER SPECIALTY CORP.

LANCASTER, OHIO

Diamond Specialty Limited, Windsor, Ontario

4139-S

CATALOG LIBRARY

This monthly list of the latest standard catalogs and bulletins is designed to aid the engineer in maintaining his permanent catalog file of engineering data. The items listed, unlike those under Helpful Bulletins, will appear each month except for additions and deletions determined by space requirements or by the manufacturers issuing the bulletins. Use the Helpful Bulletins coupon in requesting these copies.

BOILERS AND AUXILIARIES

201 **Working Pressure Data Card**—Maximum allowable working pressures for water tube and fire tube boilers are compiled in a handy reference table, Technical Data Card No. 113-A. It lists pressures in pounds per square inch for seamless and electric resistance welded carbon steel tubes or nipples for different diameters and gages of tubes conforming to ASME specifications. Chart, covers 2 letter-size pages, is printed on firm stock, and punched for use in binder. The Babcock & Wilcox Tube Co.

202 **Dowtherm Vaporizer**—Bulletin No. 48-2, describing manufacturer's Type "A" Dowtherm Vaporizer tells how this unit is designed to evaporate Dowtherm in such a way as to provide dependable operation at maximum temperatures, discussing its construction advantages in detail. It is illustrated with photos of the vaporizer and includes a dimensional drawing, vaporizer chart and specifications. Also included is table showing general properties of Dowtherm "A." The Wickes Boiler Co.

203 **Water Tube Boilers**—This 12-pp bulletin illustrates and describes special and standard power plant boilers and packaged steam generators. Includes data and dimensions. Springfield Boiler Co.

204 **Rotary Tube Cleaners** — Bulletin R-105 presents air and water driven rotary tube cleaners and cleaner accessories. Illustrates several models and heads, discussing special features. Also includes data on motors and hose for use with cleaners. Roto Div., Elliott Co.

205 **Tube Expanders**—Bulletin 380, 8 pp, covers manufacturer's line of tube expanders for maintenance of high pressure boiler tubes, superheaters, economizers, circulating tubes, steam generators and like equipment. Various models are illustrated by photo and described as to application. Also included are engineering drawings to show typical applications of one model. Accessories for tube expanders are also described and illustrated. Thomas C. Wilson, Inc.

VALVES, TRAPS, PIPING

206 **Piping Materials Catalog**—Corrosion resistant valves and piping materials are covered in illustrated circular No. 320, 32 pp. Contains information on manufacturer's complete line of valves, fittings, fabricated piping and pipe coils to meet a wide range of corrosive conditions. Listing includes both photos and cutaway drawings of models, complete specifications, sizes and prices. Includes a description of alloy metals used and a corrosion questionnaire. Also included are several pages of condensed recommendations on the selection of piping materials according to service requirements as well as a pictorial chart showing basic types of valves with names of their component parts. Crane Co.

207 **Steam and Water Mixer**—Bulletin 900-A describes company's steam and water mixer for providing hot water at isolated points. An explanation of how the mixer works accompanies a large, cutaway illustration. Includes dimensional data, sizes, capacities and prices of mixer and spare parts, also photo and sketch of typical installations. Sarco Co., Inc.

208 **Pipe Hanger Catalog**—Ninety-page Catalog 10-D is a valuable buyer's guide for adjustable pipe hangers and supports. Covers hangers for attachments to pipe and to structure, hanger assemblies, spring hangers, hanger rods, pipe supports and related equipment. Each type described and illustrated by photo and dimensional diagram and listed with dimensions and prices. Catalog also includes standard specifications, photos of installations and terms of sale. Indexed for quick reference; punched for filing in binder. Grinnell Co., Inc.

209 **Valves Bulletin**—A new catalog section 12-H describes all types of the company's cast steel pressure-seal bonnet valves. Information on choosing the best size valve for your service is given in one page of the booklet under the title, "Correlation of Valve Size and Pressure Drop." Design and construction advantages of the valves are given and tables of pressure and temperature ratings. Details of design including operating mechanism, body design, disk piston, and other features are explained. Dimensional details are given in tabular form accompanied by dimensioned line drawings. A standard materials specification table is presented. Edward Valves, Inc.

210 **Rubber Expansion Joints** — This 8 page bulletin AD 137 tells about the application, construction, styles, service and advantages of the company's line of rubber expansion joints. Other information given, includes "How To Order" and a table of dimensions which is accompanied by dimensioned line drawings. The bulletin is well illustrated. The Garlock Packing Company.

211 **Control Equipment**—General Catalog 001, 30 pp, is devoted to measuring and control equipment for water and sewage works, power and processing industries. Catalog illustrates and describes in detail: venturi tubes and meters, controllers, gages, manometers, pitot equipment. Includes capacity tables, dimensional data, specifications, layout drawings. Simplex Valve and Meter Co.

211A **Flanges for Severe Service**—This 4-pp bulletin describes and illustrates a flange specified for services involving severe abrasion and corrosives, and for use in suction and discharge service. Photos and sketches illustrate the flange and its parts. Bulletin also covers a flexible rubber pipe for use with abrasive or corrosive material, as well as an acid- and corrosion-resisting duct, listing solutions this duct will handle. Goodall Rubber Co.

212 **Steam Traps**—Catalog 448, 32 pp, provide dimensional, application and engineering data on company's line of steam traps. Includes prices and weights and ordering information is generously illustrated. Covers industrial steam traps, expansion steam traps, weight-operated and piston-operated types, continuous flow gasoline trap, separators and related equipment. W. H. Nicholson & Co.

213 **General Service Valves** — Bulletin E-160, 16 pp, describes and illustrates the design and construction of company's quick-operating valves, explaining their application to blow-off service and on fire protection, chemical process, soot blower, water column blow-down, and other types of pipe lines. Included are tables of dimensions, weights and list prices for straight lever and rack-and-pinion types. Inside packed and with outside stuffing box and with screwed or flanged ends. Everlasting Valve Co.

214 **Unions and Fittings** — Twelve-pp Catalog 50 covers manufacturer's line of unions of all types, elbows, tees and fittings. It describes and illustrates special construction features and other advantages. Also illustrates all equipment offered, along with sizes and materials available. Catalog is accompanied by current price list. E. M. Dart Mfg. Co.

215 **Strainers**—Bulletin S-202, 4-pp, describes and illustrates company's fine screen strainers for steam traps, reducing valves and other pipe line equipment. Tells why strainers are needed; discusses special features and construction details of these strainers. Includes pressure and screen data tables, suggestions for installing, and dimensions, weights and prices. Yarnall-Waring Co.

HEATERS, HEATING

216 **Packaged Heat** — Unit heaters featuring low first cost, easy installation and continued low cost per Btu are presented in this 12-pp booklet. Text explains how these packaged heaters are designed to operate instantly on oil or gas, fit heat output to requirements of day, and provide heat where it's wanted. Illustrations include photos of heaters and several installations and many sketches showing advantages and construction details. Prat-Daniel Corp.

217 **Tubular Heat Exchangers**—Bulletin 916, 32 pp, describes present designs of the company's tubular heaters, coolers, condensers and heat exchangers and their distinctive features. The various types of shells, tube bundles, stationary heads and floating heads are fully explained, together with statements of the particular services for which each is suitable. An additional helpful feature of the bulletin are tables of the characteristics of tubing, the thermal resistance of tubes and pipes of many different metals and alloys, and the specific gravity and pounds per gallon corresponding to degrees Baume and API. Also presented are charts of specific heats of midcontinent crude oils and for solving MTD formula with correction factors for other than countercurrent conditions. The Griscom-Russell Co.

218 **Chemical Soot Removal** — Ten-pp Bulletin 45, on the chemical removal of soot from boiler furnaces, explains the research work that led to the development of manufacturer's new chemical soot remover and slag alleviator for coal fired boiler furnaces. It tells how this combustion catalyst prevents soot formation on furnace internals and helps to end the smoke problem. National Aluminate Corp.

219 **Water Heaters**—Illustrated 6-pp Bulletin 70, Section I, on instantaneous type water heaters contains detailed capacity and dimension tables for two-pass, four-pass and six-pass designs, with tube bundles removable for inspection. A typical piping hook-up for installation of these heaters is shown. Also included are instructions for heater selection, engineering data to determine boiler capacities required for heating water, and a chart to determine pipe sizes for any steam flow at most pressures. Davis Engineering Corp.

220 **Tubular Heater**—A simplified vertical tubular heater suitable for every process duty and designed to hold initial and maintenance costs to a minimum, is the subject of 4-pp Bulletin 0-49-7. Includes a complete description of this simplified design which features the use of bare tubes and the absence of any metal parts exposed to furnace gases, also a discussion of the design's advantages. Cutaway drawings illustrate text. Foster Wheeler Corp.

221 **Condensate Drainage Control** — Manufacturer's system of high-pressure and high temperature condensate drainage control is fully explained in 24-pp Publication No. 3250. Contains useful data on steam flow conditions and heat exchange characteristics. Gives material and operating specifications and capacity ratings for both standard and high differential units in six sizes from 3 to 25 hp based on a maximum of 200 psi above process pressure. Differential pressures to 200 psi are listed and capacities for each unit tabulated for unit inlet pressures. Illustrations include photographs and dimensional drawings in color showing design and construction of both types of units. Cochrane Corp.

WATER TREATING, CORROSION PREVENTION

222 **Water Conditioning Bulletin**—This is an eight-page discussion of water and chemicals developed for conditioning it to control scale and algae and inhibit corrosion. Describes several chemicals in detail, giving properties, composition and application. Also discusses special purpose chemicals. Wright Chemical Corp.

223 **Corrosion Analysis**—Excellent working data on galvanic corrosion is contained in this 8-pp technical study of corrosion by concentration cells, reprinted from Inco Corrosion Reporter, Vol. 3, No. 1. Discusses concentration cells, the metal-ion cell type, oxygen cell type, reversible concentration cells, their practical aspects and some rules for minimizing or preventing concentration cell corrosion. Illustrated with sketches showing conditions which accelerate corrosion. The International Nickel Co., Inc.

224 **Corrosion Resistance of Nickel Alloys**—Technical Bulletin T-3 contains 44-pp of illustrated information on the resistance of high nickel alloys to corrosion by sulfuric acid. Although technical in nature, it is written so as to be readily understood by non-technical staffs. Per-

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formance of 36 nickel-bearing materials in a wide range of service is discussed, and there are 88 tables and 33 graphs and photos in addition to text. Problems involving a wide range of operations from the pickling of steel to petroleum refining and textile processing are covered. The International Nickel Co., Inc.

225 **Cleaning Industrial Equipment**—This is a general information bulletin on manufacturer's service for cleaning steam generating, heat exchange and other industrial equipment. Also included is information on pipe line cleaning and water well acidizing. Illustrations of these services are included, and bulletin treats in detail the methods used to remove incrustations from internal surfaces economically with minimum of downtime. Dowell Inc.

226 **Anti-Foam Treatment** — This 4-pp bulletin covers a new formula in powder form to be applied along with anti-scale treatment for improving steam quality, controlling scale in boiler feed system and sludge conditioning. It discusses the problem of steam contamination and explains the action of this polyamide anti-foam treatment. Tells how it should be applied and gives dosage requirements. A discussion of its advantages is accompanied by photos showing the effect of polyamide action on a boiling dilute Nacconol solution. Dearborn Chemical Co.

227 **Boiler Corrosion**—A 12 page article discussing the cause and prevention of corrosion in boiler systems is presented in **Beta Technical Paper No. 111** titled "Corrosion: Its effect in Boiler Systems." The corrosive effects of oxygen, carbon dioxide, ammonia, hydrogen sulfide, acidity and physical factors are evaluated. Numerous illustrations, graphs and tables aid in understanding the article. W. H. & L. D. Betz.

228 **Turbine Blade Deposit Study**—Identification and prevention of steam turbine blade deposits and boiler water conditioning to prevent such deposits are discussed in the new 16-pp illustrated Bulletin 28B7030. Describes x-ray diffraction methods employed by the company for identification purposes and the results obtained. Tables list the partial chemical analyses of deposits containing sodium disilicate, occurrence data on compounds found, composition of turbine deposits from turbines operating at various throttle pressures and temperatures, and comparison of compounds found in turbine blade deposits with boiler operating pressures. Allis-Chalmers Mfg. Co.

229 **Boiler Water Manual**—Factual information on standard methods of applying chemicals in the treatment of water for boilers is presented in this 16-page technical bulletin, called Standard Method 122. Discusses pretreatment of raw water, application of chemical feeding to pretreating operations and both constant rate and flow responsive feeding direct to boiler drum and to feedwater systems. Also discusses condensate returns, flushing periods, condenser cooling water treatment and chemical tanks. Illustrations include photographs of two feeders and diagrams of the various methods described. Punched for filing. %Proportioneers, Inc %.

230 **Water Softener Equipment** — How the problems caused by hard water can be offset by the use of water softeners is explained in Bulletin 2386, 12 pp, describing ion exchange equipment. It covers in detail downflow upflow and gravity zeolite water softeners. Contains a 2-pp cutaway illustration of a fully automatic softener to show how an ion exchanger is built and how it works. Bulletin also contains flow diagrams showing arrangements for installation of water softeners and includes detailed, illustrated discussion of multiport valves used in them. The Permutit Co.

231 **Corrosion Treatment** — "Corrosion Protection of Steam and Condensate Return Systems" is a 4-pp folder covering a recently developed amine treatment for inhibiting of boiler and condensate systems. This treatment is described as affording surface protection of the metal itself as well as raising the pH value of the condensate. Booklet gives specific case histories and typical economies obtained by power plants using this treatment. Includes graphs showing relationship between free CO_2, pH and alkalinity in water, and the solubility of oxygen in water when exposed to air at various pressures. The Bird-Archer Co

232 **Chemical Feed Systems** — Single, complete "packaged" units for feeding directly into boiler feed water lines are the subject of 4-pp Bulletin 4811. It discusses in detail sodium sulfite feeding, internal treatment, chemical feeding, manual control, intermittent feeding of internal treating chemicals; automatic feed systems; automatic pH control, and automatic control by conductivity. Illustrations include photos and diagrams of controlled volume pumps and a typical packaged installation. Milton Roy Co.

233 **Modern pH and Chlorine Control** —The new ninth edition of this 100-pp illustrated 6 by 9 in. paper-bound booklet has been revised to conform with the latest developments and most modern practice in water treatment. But it is much more than a catalog, although it does give full technical details of all the color comparators and equipment in water testing and control of boiler and industrial process water manufactured by this company. Its most important feature, however, is inclusion of much good technical information on the meaning of pH control, electrometric and colorimetric methods of determining pH and also determining constituents in water; applications of water control in air conditioning; treatment of boiler feed water and industrial water, and other industrial applications. Descriptions of color comparators are detailed and illustrated, with the prices listed; and include a new testing set for total hardness of water (technical details given in article in January, 1950, issue of POWER GENERATION). W. A. Taylor & Co.

234 **Hydrogen Zeolites in Water Softening**—Described as one of the few reports published on the results obtained from organic zeolites in the hydrogen cycle with acid regeneration is Article TA-115, 12 pp, written by V. J. Calise. In addition to presenting operating data from several commercial hydrogen zeolite installations, the paper also explains applications of acid-regenerated zeolites, compares sulfonated coal type and resin type zeolites, new safeguard for oil and gas fired furnaces, ovens, boilers, kilns and other heating equipment. The safety features and economy of the new control are described and illustrated and a typical application diagram is included. Bulletin also includes selection chart covering several control units. Wheelco Instruments Co.

ELECTRICAL

235 **Large D-C Motors**—Latest construction features of manufacturer's large d-c motors for applications requiring wide speed variation and fine speed control are discussed in 40-pp Bulletin OB56002A. Included is a comprehensive description of "frog leg" armature windings, a combination wave and lap winding that gives good commutation without cross-connectors and views of the new style mill-type spherical seated thrust bearing with welded-steel pedestal for heavy service. Controls for the motors, currently being used to drive metal rolling equipment, mine hoists, paper machines rubber mill rolls, plastic calendars and traction equipment are also covered. Allis-Chalmers Mfg. Co.

236 **Synchronous Generators**—This Bulletin, 05B6139A, describes construction features and electrical characteristics of engine-type synchronous generators in standard ratings from 25 to 10,000 kva and for standard speeds from 100 to 600 rpm, for Diesel, steam or gas engines. Also describes and illustrates mechanical construction of stators and rotors and discusses machine characteristics, ratings, voltages, frequencies, phases, temperature rises and operation at high elevation. Illustrations show typical installations. Available control accessories are listed, as are manufacturer's other products and territorial sales offices. Allis-Chalmers Manufacturing Co.

237 **Synchronous Motors — High speed** synchronous motors are described in 4-pp bulletin PB 5600-1. The bulletin is packed with descriptive matter and photographs explaining features of the motors rotor and stator. Mechanical modifications also are illustrated. Elliott Co.

PUMPS, COMPRESSORS, ENGINES

238 **Steam Engine Governor Data**—This new bulletin No. 502, describes the company's Type EN fully enclosed self-lubricated governor which is described as giving "precise, dependable engine speed control." Illustrations of the unit are presented and a parts list, accompanied by a sectional diagram is given. One section "Installation and Care" tells how to assemble governor to engine cylinder and how pulleys should be proportioned, the proper type of belt for use with the governor, correct lubrication procedure, method of packing and other data. Troy Engine & Machine Co.

239 **Condensers**—Bulletin 441-C, 28-pp, covers in detail every phase of manufacturer's line of condensers—their simplicity of design, accessibility, construction features. Illustrated with photos and drawings showing complete assemblies, parts, principles of operation. Bulletin also discusses emergency replacements, service and maintenance facilities available, and auxiliary equipment. Includes condenser tube data, pressure-conversion tables. Condenser Service & Engineering Co.

240 **Compressor Selection Chart**—Here's a new selection chart, based on normal applications handling air with atmospheric intake pressure. It simplifies selection of proper size compressor for average industrial use, with quick comparison between discharge pressure pounds per square inch gage and piston displacement cubic feet per minute and shows recommended compressor bore and stroke in inches. Chart covers two letter-size pages. Worthington Pump and Machinery Corp.

241 **Air Compressor Lubrication Manual** —Valuable information on air compressor maintenance is contained in this 40-page book on the lubrication of air compressors, second edition. Subjects treated include compressed air, compressors and related equipment, lubricating systems, compressor oils and their applications, lubrication requirements operating hints, oil requirements, storage and care of compressor oils, and safety precautions. All discussions are illustrated with large, clear photographs and drawings showing construction and operation of compressors their lubricating systems, etc. Cities Service their lubricating systems, etc. Cities Service Oil Co. (In the South, Arkansas Fuel

242 **Steam Pumps** — This is manufacturer's collection of bulletins covering all types of centrifugal and reciprocating pumps for a wide range of industrial uses. Contains more than 80 pp in all and includes photos, dimensions, specifications, ratings and application data. Warren Steam Pump Co.

243 **High Vacuum Apparatus** — This 50-pp handbook, Bulletin 10A, covers vacuum pumps and accessories and furnishes excellent engineering data on planning high vacuum systems. Contains illustrations, specifications and dimensions for many types of vacuum pumps, gages, burners, lubricants and other accessories. Prices and ordering information included. Central Scientific Co.

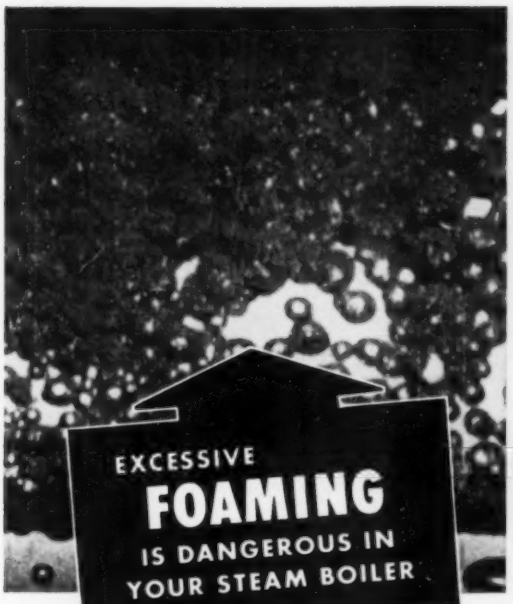
INSTRUMENTS AND CONTROLS

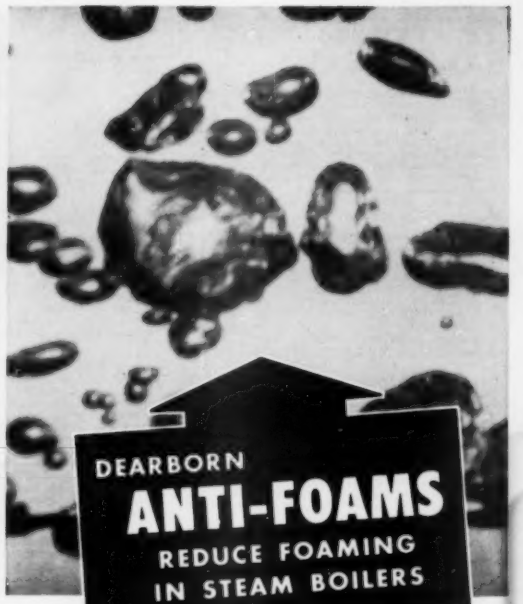
244 **Smoke Density Recorder** — Bulletin 211, 4 pp, tells how company's bolometer-type smoke density recorder promotes efficient furnace operation and how it helps in the battle against smoke nuisance. It describes and illustrates the smoke detector which consists of a bolometer receiving and measuring radiation from a sealed beam light source. Recorder specifications, installation requirements, and measuring circuit details are also discussed. Bailey Meter Co.

245 **Boiler Water Level Control** — Bulletin 487 describes completely the installation of boiler water level control equipment at the Blackhawk Generating Station, Wisconsin Power & Light Company. Photographs of the installation are presented as is a schematic layout of the entire station along with tabulated significant data. A large, full-page cross section of the B & W Type FH integral furnace boiler is presented and other drawings and photographs show accompanying equipment. Northern Equipment Co.

246 **Water Gages** — Eight-page Bulletin E-1 covers line of water gages for stationary and locomotive boilers, marine and refinery service and tanks for all pressures and temperatures. Listings include photos of all gages, sizes and construction details. Bulletin S-2, four pages, covers gage glasses, glass guards, sight flow indicators and related equipment. Ernst Water Column & Gage Co.

247 **Temperature Measuring Instruments** —For all those responsible for the safe operation of electric power equipment, this company has just issued a revised 24 page catalog ND4-33-461 describing the company's instruments for measuring the temperature of generators, motors, condensers, transformers, etc. The bulletin covers a wide variety of instruments, portable and automatic indicators,





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Excessive foaming in steam boilers is the cause of needless delays, shutdowns and expense. Dearborn Polyamide Anti-Foams produce purer steam . . . eliminate scale formation in feed lines, enclosed heaters and economizers . . . prevent carry-over of suspended or dissolved solids which may foul equipment and spoil materials . . . condition sludge . . . are compatible with other treatment.

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for checking in any order on temperatures. Reference also is made of new and specialized instruments for measuring in rapid succession a number of bearing temperatures. Leeds & Northrup Co.

248 **Recording Instrument Data Book**—An oxygen-analyzer, based on the para-magnetic property of oxygen, is described and illustrated in Bulletin 49-B29, 16 pp. Tells advantages and applications of the instrument; also discusses manufacturer's analyzer for carbon dioxide and other gases and an electronic recorder (temperature and pressure) for use with analyzers. Describes several recommended gas sampling systems. The Hays Corp.

249 **Metering Chlorine** — Bulletin 640-F2 describes an instrument designed to accurately meter chlorine gas and deliver a chlorine water solution to the point of application. Discusses the safety and other features of the instrument and explains its operation and maintenance. Illustrations include photos, a phantom drawing showing principle working parts, and a layout diagram. Builders-Providence, Inc.

250 **Purity Indicator**—An instrument for measuring and indicating electrical conductance of steam and water is described and illustrated in 8-pp Bulletin 11-23-48 RCD. It discusses problems encountered with steam and condensate purity and cites examples of how controller and alarm assembly are utilized in detecting and signalling impurities caused by carry-over and condenser leakage. Includes photos of typical test apparatus, also prices. E. F. Drew & Co., Inc.

251 **Flow Meters** — Illustrated Bulletin M-51, 4 pp, explains how automatic compensation for pressure or temperature variations, or both, are achieved in flow measurement of gases or liquids with company's compensated meters. A schematic diagram shows how a corrected record is automatically and continuously produced, with the chart also showing uncorrected flow. Another diagram illustrates installation of a pressure and temperature compensated flow meter, and photos show the meters equipped for compensating functions. Hagan Corp.

252 **Multiple Signal and Alarm Systems** — Panalarms, multiple signal and alarm systems adaptable to all types of industrial and power plant applications, are described in 12-page, letter-size, illustrated Series 300, Panalarm bulletin. Gives details of operation, shows types for panel and wall mounting, wiring circuits, operation sequence, dimensions of units. Shows how Panalarms indicate by light and horn signals, acknowledging button, for normal and abnormal conditions. Systems are supplied in multiples of up to 12 in single cabinet; extra space for spare units; provisions for future additions; simple field wiring. Price list included. Panalarm Products, Inc.

253 **For Practical Men**—That's the title of this 24-pp pocket-size booklet presenting insulation testing in simple language. Packed with maintenance hints, it explains electrical insulation, tells how it can be tested and what makes it go bad. It describes the Megger insulation tester and justifies its cost in terms of long run economy and prevention of shutdowns. Discusses the Megger as a trouble-shooter, pointing out its functions and telling how to get the most out of it. There's also a chapter on handling wet equipment. Photos, line drawings and humorous sketches accompany the text. James G. Biddle Co.

COAL HANDLING

254 **Screw Conveyor**—Two-pp Form A-84 describes a high-speed, direct-feed, bin-to-stoker screw conveyor that comes ready to set up. Illustrations show this conveyor in use and detail of its principal parts. Stresses economy of this conveyor in handling coal and includes specifications. Baughman Mfg. Co., Inc.

255 **Coal Scale Data Book**—The answers to a power engineer's questions on coal scales are provided in this excellent 48-pp book, Bulletin 1143, covering scales for recording weight of coal consumed by individual boilers and weight of coal receipts from ship, car, truck or storage. It is generously illustrated with photographs of models and accessories and actual plant installations and contains all necessary engineering drawings, dimensional data and detailed specifications. Construction features and operation of weighing and feeding systems are described. Richardson Scale Co.

256 **Spreader Stoker Selection** — Four-teen-pp Form F-520-A10M is intended to help those choosing a spreader stoker to get the most for their investment, and it points out many factors to be considered in the selection. It pictures and describes in detail the principle operating parts of manufacturer's stokers, emphasizing their advantages. Includes engineering drawings and photos of typical installations. American Engineering Co.

257 **Coal Crusher**—In this 8-pp bulletin a rolling ring crusher is presented as a solution to the problem of uniform stoker coal. Describes the special features of this crusher, emphasizing its shredder designed to split coal rather than crush it. Gives speed, capacity, weight and dimensions of available models and illustrates principle of operation. Also contains photos of parts and several complete installations. American Pulveriser Co.

258 **Underfeed Stokers**—Bulletin 350, 24 pp, features a single retort underfeed stoker which may be operated by electric or steam drive. It is described as a complete firing unit for burning various grades of bituminous coal with high efficiency for boilers from 50 to 150 hp rated capacities. Generously illustrated, the bulletin explains the operation of these stokers, tells their applications and economy and gives sizes and capacities. Also contains installation photos and diagrams. Detroit Stoker Co.

259 **Coal Handling Equipment** — Modern equipment for the storage and handling of coal and ash is presented in 24-pp Bulletin 300. Illustrated with sketches and photos of actual installations, it covers concrete and tile silos, cylindrical steel tanks, and suspended steel bunkers with gravity discharge bucket elevators and pivoted bucket carriers. Also describes and illustrates a skip hoist and other auxiliary equipment. Gifford-Wood Co.

TURBINES

260 **Turbine Catalog Collection**—This is a valuable collection of bulletins in loose-leaf form. They cover a complete description of manufacturer's solid wheel turbines and feature cross section drawings of typical units for both moderate and high steam pressure conditions. Also provides a description of an axial flow impulse, both single and multi-stage, and complete data on speed increasing and speed reduction gears. The Terry Steam Turbine Co.

261 **Velocity Stage Turbines** — Catalog 82-19R, 8 pp, features turbines for mechanical drives designed to operate under all inlet steam conditions up to 600 psig and 750 F. Gives complete specifications, dimensions and includes chart showing how to estimate turbine sizes. Illustrations include cutaway view, photos of parts. Speed governor and regulating valve, and emergency governor and trip valve are described in detail. De Laval Steam Turbine Co.

262 **The Answers on Turbine Oil**—This 2-pp booklet answers several questions power engineers ask about turbine oils, including: What causes deposits of sludge? What causes acidity increase? What causes corrosion in turbines? Explanations are brief but thorough. Booklet is illustrated with photos of turbine installations in which manufacturer's products have been used successfully. Standard Oil Co. (Indiana).

DUST COLLECTING

263 **Fly Ash Elimination** — Power engineers will find this 30-pp booklet outstanding among material on this subject. It presents manufacturer's "Multiclone" equipment described as small-tube type of cyclonic dust collectors using centrifugal force for separating dust from gas stream) as a highly successful and economical means of separating fly ash—not as a panacea for all cinder and fly ash problems. Parts and assemblies are illustrated by photos and drawings and explained in terms of construction, operation and capacities. Particle size and its significance in fly ash elimination, is discussed in detail and so is dust collecting efficiency as affected by operating conditions. Book also contains excellent engineering data on single and double hopper installations and several diagrams of typical arrangements. Western Precipitation Corp.

264 **Dust Collectors** — Dust collecting equipment for power plants, foundries, cement plants and similar industries is the subject of Bulletin No. 1428, 26 pp. Contains many photographs of installations, also photos showing equipment being tested in company laboratories. Discusses services offered by manufacturer in analyzing individual installation requirements and recommending equipment for the job. American Blower Corp.

MISCELLANEOUS

265 **Pump Packings**—Packings for use on reciprocating and centrifugal pumps are illustrated by photo and described in this 4-pp folder. It covers packings for practically all services and includes a table of recommendations to facilitate selecting the right packing for any particular application. Johns-Manville.

266 **Concrete Floors Q & A** — A new booklet titled Lumnite Concrete Floors—Corrosion Resistant and Heat Resistant, has just been published. The detailed information contained in this booklet brings up to date, the service experiences and late developments in this field. The information covers methods and materials used in placing corrosion resistant concrete in a wide variety of industrial applications. Typical uses of corrosion resistant concrete are listed for many industries and also given, are the answers to a number of questions often asked about it. A section on placing and finishing corrosion resistant floors will be helpful to prospective users. Lumnite Division, Universal Atlas Cement Company.

267 **Tube-Ice Machine** — Bulletin TI-3 describes manufacturer's automatic ice-making machine for producing either cylinder or crushed ice. Explains and illustrates machine's operation, discussing its small space requirement, quick freezing time, reduced power consumption and economy. Its application in the dairy and packing industries, breweries, chemical plants, institutions, and ice plants are described and pictured. Also discussed is the utilization of this machine in cold water refrigeration for air conditioning systems. Includes chapter on the handling and storage of ice. Henry Vogt Machine Co.

268 **Purger Bulletin**—How air and other non-condensables get into refrigeration systems; the adverse effect of this on operating costs and efficiency and what manufacturer's forged steel purger does to prevent it are covered in 8-pp Bulletin 192. Also included are installation data with illustrations and diagrams, specifications and prices, helpful charts and tables. Armstrong Machine Works.

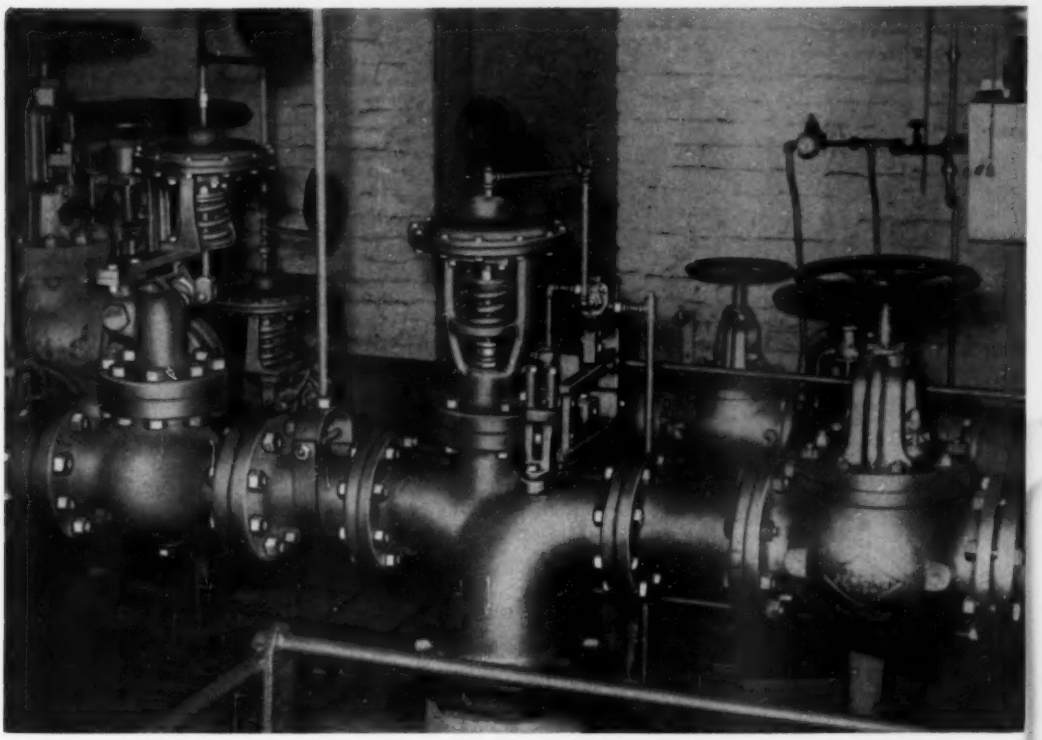
269 **Water Hardness Test**—This technical bulletin presents a test procedure for determining hardness of water, by use of a color indicator which is described as both easy and accurate. Instructions for running the test are illustrated in color. Includes prices of company's complete hardness titration set and individual solutions used. W. H. & L. D. Betz.

270 **Car Spotter** — Book No. 1992-A, 16 pp, illustrates and describes car spotters in three types and two sizes for a variety of car moving jobs, many of which are illustrated by photos. Book contains photos of various models, dimensional drawings, electrical characteristics, weights and prices. Also covers accessories for use with spotters—rope, hooks, sheaves and snatch blocks, as well as drum type car pullers for heavy duty service. Link-Belt Co.

271 **Welding Fittings and Flanges** — Titled "Catalog and Engineering Data Book 211," this handsomely bound 262-pp manual provides complete dimensional data, weights and prices on company's welding fittings and flanges. The engineering section contains practical, illustrated information covering welding fittings and flanges under varying conditions of temperature and pressure, location and materials processed. Discusses their use in different types of piping systems.

A section is devoted to welding fittings and flanges in special metals and alloys and their specific applications. The technical section covers properties of pipe, rating of pipe, fittings and flanges, line expansion and flexibility, support and anchorage of piping and flow of fluids.

(Continued on page 128)



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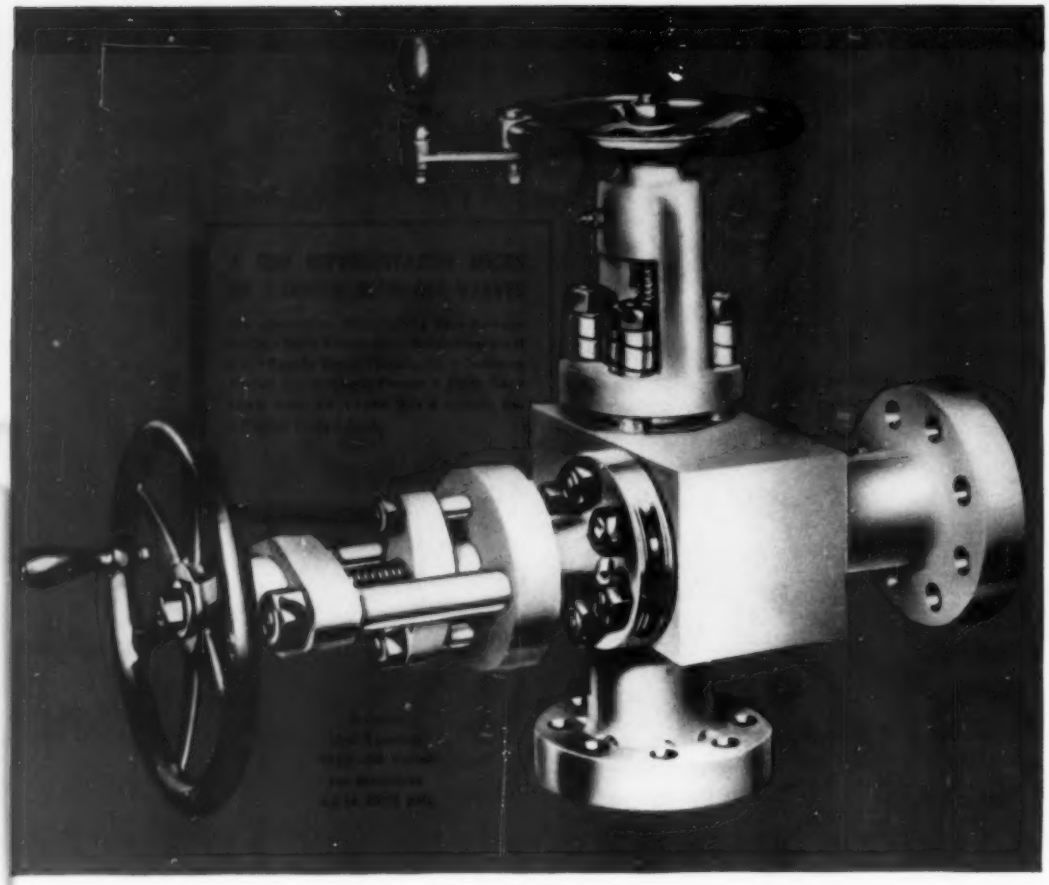

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The Yarway Unit Tandem Blow-Off Valve meets the most demanding requirements for boiler blow-down or drain service.

It's drop-tight—and rugged enough to withstand the severe punishment of regular or emergency blow-down under pressure, or periodic acid wash.

Two Yarway Stellite-Seat Hard-Seat Valves or a Hard-Seat (blowing) and Seatless (sealing) Valve are combined in a one-piece forged-steel body. Designed for pressures up to 2500 psi.

It is significant that more than 4 out of 5 high pressure boiler plants use Yarway Blow-Off Valves.

For more facts, see Yarway Bulletin B-432.

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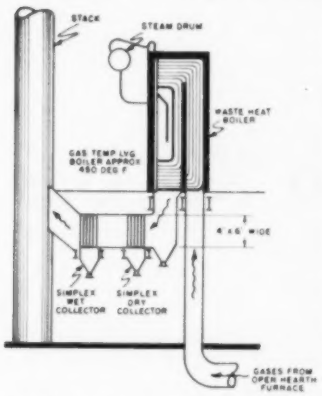
YARWAY **BLOW-OFF VALVES**

LETTERS TO THE EDITORS

HOW TO REMOVE DIRT FROM STACK GASES

SOME TIME ago you described a venturi scrubber in the pages of *Power Generation* which was designed to remove dirt from stack gases. This article brought to mind a system of dust removal the writer installed in a large industrial power plant in Philadelphia in 1932. This installation had two 300,000 lb per hr boilers. We introduced water into the stack of these boilers. Then



Method of cleaning gases from waste heat boiler

the dirt was settled out and the water returned for further use.

The accompanying sketch shows a system we developed for removing the dirt from waste heat boilers operated in connection with open hearth furnaces. Here we use a dry cleaner and a wet cleaner in series as shown. This system has proved completely satisfactory in washing the dirt from the stack gases.

Wyncote, Pa. J. P. BADENHAUSEN

WHAT MAKES AN ENGINEER?

THE QUESTION OF "what" makes "who" an engineer has as many answers as there are engineers. It reminds me of the story of Dean Barker, formerly of the Columbia School of Engineering, who was fond of telling of the mother who visited him about selecting a field of study for her young son. The mother related the boy's ingenuity in wiring the house, repairing the car, constructing a workshop etc. After listening to her story, Dean Barker replied, "My dear woman, there is a big difference between a mechanic and an engineer," and he paused, adding, "a good mechanic makes more money."

But the best definition that I have heard, is that an engineer can do for one dollar what any d—n fool can for two!

Formal education is not a prerequisite yet many graduate engineers continually take part-time courses to increase their field of knowledge. In addition, engineers keep abreast of new developments by reviewing current publications, and subscribing to periodicals dealing with their field.

Membership in engineering associations does not make an engineer: yet the engineer extends his field of contacts and widens his viewpoint through his membership in one or more of the 74 engineering societies.

Operation and knowledge of equipment, alone, cannot either be taken as a criterion of engineering; it applies equally well to many automobile drivers. But it is in the study of the operation of equipment and extending its limits, increasing its efficiency, making it safer, or improving it in other respects that we find the real application of engineering principles.

All states have legal requirements for the title of Professional Engineer. In most states, it is necessary to meet these requirements in order to be able to advertise engineering services, sign official papers etc. To obtain a license to practice a good many years of engineering experience are required, some of which may include formal engineering education. Some state laws require, in addition, a written examination.

The value of state registration to engineers is the elimination of the need of engineers to continually prove their qualifications to practice. It is ridiculous to consider cross-examining a doctors qualifications on each visit, yet the unregistered engineer finds that he may be considered a "technical aid" in one organization, an "engineering clerk" in another, an "operator" in a third, or a "draftsman" in a fourth organization. These classifications may be arbitrarily assigned without any recognition of the fact that the position does, or does not require the service of an engineer.

Aside from titles and definitions however, the engineering train of thought combines service to the public (Safety), service to the employer (Efficiency), and service to himself and to his profession (Self-Improvement).

Can Engineering Thought be summed up by any definite laws?

Foremost would be the law of cause and effect, or more importantly stated: Every effect has a definite cause, known or unknown. And every change gives rise to new effects which must be examined before they are allowed to occur. In Newton's language, every action has a distinct and separate reaction.

The Engineer searches for the unknown causes of observed effects, while he is always on his guard against undesired effects created by changes he puts into operation. He can afford to take nothing for granted. In this manner he protects the safety of all who come in contact with his work.

And possibly a second law can be added; everything is capable of improvement. It is necessary for the engineer to use his imagination to visualize methods of increased performance and to assess their value and their cost. Improvement can come from the fruits of recent developments, or from the forgotten results of past experience and frequently results from a combination of both. It is here that we find education and experience solidly linked together.

But of one thing we are sure. The engineer is equally the foe of the *status quo*, and of untried, unproved conjecture.

New York, N. Y. H. I. PODELL

DOCTORS AGREE—AND DISAGREE

NOT OFTEN am I moved to write to the editor, but two stimuli in your February issue are more than I can withstand.

I congratulate you on the article on page 54 on purging systems for hydrogen-cooled machines. It is delightful to see a publication that is not afraid of presenting a long article that tackles a complex subject and finishes it. Some people seem to believe that nobody reads beyond the first page, a belief I do not share.

On page 79, Mr. Darnell complains that published data on gas densities scatter over a wide range. This is hardly surprising in a collection of data from various sources measured at various times and under various conditions. He uses the ideal gas law and molecular weight ratios to compute values for comparison, which he hopefully calls the "correct" values.

Unfortunately, real gases do not follow the ideal gas law closely, especially those with high critical temperature, such as carbon dioxide. The compressibility factor F in the modified ideal gas equation, $p\ v = F\ R\ T$, varies over a considerable range, above and below unity. See, for example, Marks' Handbook, fourth edition, page 311 and the

(Continued on page 126)

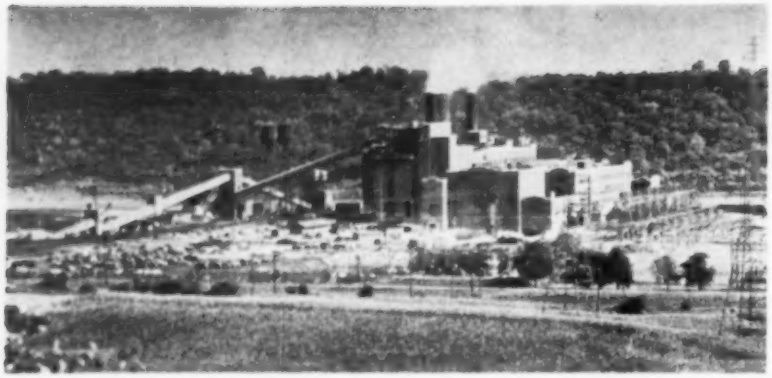


Fig. 1. An exterior view of Miami Fort Station of The Cincinnati Gas & Electric Co. Located on the Ohio River about 20 miles west of the center of Cincinnati, this station today has a total capacity of 336,000 kw

MIAMI FORT Station Adds 80,000 Kw Unit

By B. J. YEAGER
Mechanical Engineer, Electrical Production Department
The Cincinnati Gas & Electric Company
Cincinnati, Ohio

MIAMI FORT STATION, located on the Ohio River 20 mi west of Cincinnati, was placed in operation in 1925. At that time it was known as Columbia station. Rebuilding and expansion in 1928, 1938 and 1942 made this station the largest of the two stations on the Cincinnati Gas & Electric System. Power from this station is transmitted over 33 kv, 66 kv, and 132 kv transmission lines.

The first post-war increase in generating capacity to meet the growing needs of the Cincinnati system was the installation of a 35,000 kw superposed unit in the West End Station, raising the generating capacity at this station to 214,000 kw. This installation was authorized in May, 1946 and placed in service December 1, 1948. The station is completely rehabilitated and consists of 6 high pressure boilers, two superposed turbines and the original 4 condensing turbines. All of the low pressure boilers (originally 14) are now removed, making the station completely high pressure and placing the entire Cincinnati System on pulverized coal as the primary fuel.

Unit No. 5 represents the second phase of the post-war increase. This unit at 80,000 kw name plate rating raises the station capacity from 256,000 kw to 336,000 kw with a maximum capability of about 355,000 kw.

The authorization for construction of the unit was made in December, 1946, ground broken in July, 1947, and placed in operation in November, 1949. The construction schedule was adapted to the stage conditions in the Ohio River, that is, the condenser well was sunk in the latter half of 1947; and the building of the water tunnels and foundations was postponed until the spring of 1948, after the flood danger had passed. The Ohio River at Cincinnati has a wide range of possible stage, from a pool of about 11 ft to a maximum (1937) of 80 ft. After the record flood of 1937, which resulted in construction for flood-proofing operations, units No. 3 and No. 4 were installed with the boiler room basement set at the turbine room elevation of 511 ft. This unit likewise is placed at the 511 ft elevation which is equivalent to about an 87 ft flood in Cincinnati. The space underneath the basement which is 18 ft above grade is being utilized as a garage for the storage and maintenance of tractors, carry-all

On page 1120 of the November 1, 1925 issue of ***Power Plant Engineering*** we presented an article entitled, "Columbia Power Station Begins Operation Nov. 12. This is almost 25 years ago. Columbia station began operation with an installed capacity of 90,000 kw in two 45,000 kw units, but as reported in our article the plant was planned so that 6 or 8 additional units of the same capacity could be installed. The load grew rapidly and additions were made in 1928, 1938 and in 1942, making this station, now called the Miami Fort Station, the largest of the two stations on the Cincinnati Gas & Electric Co. system. This station for many years held an enviable record for economy and was one of the outstanding power stations in the nation. Now, a new unit has been installed, Unit No. 5, an 80,000 kw, 1250 psig, 950 F turbo-generator together with two 410,000 lb per hour boilers. At this maximum rating, the unit will generate 90,000 kw. The design heat rate, at 80,000 kw output is 11,230 Btu per kwh. With the installation of this new unit Miami Fort Station will have a capacity of 336,000 kw with a maximum capability of 355,000 kw. Unit 5 went into service November, 1949. Miami Fort Station is located on the Ohio River about 20 miles west of Cincinnati, Ohio.

and associated coal handling equipment.

The estimated final cost of the unit is $12,500,000. This figure includes the cost of all equipment up to the step-up transformer, the added cost for accommodating the future 6th Unit exclusive of the space for the boiler, the building addition for new locker rooms for the entire plant personnel and the new addition for the visitors' quarters and gallery. The visitors' section consists of a 5 story addition which is made up of a visitors' entrance and reception on the first floor, lounge facilities on the second floor, a view into the boiler room from the third floor, access to the visitors' gallery overlooking the turbine room from the fourth floor with an elevator machinery and air conditioning equipment room on the fifth floor.

The main building is constructed of steel, concrete and brick and conforms architecturally with the existing plant. The condenser well, constructed of reinforced concrete, has an inside diameter of 70 ft, and was sunk to an elevation of 415 ft. The well was sunk by the open dredge method, as was the main building caissons.

Since the turbine room, pump bay and boiler room is an extension of the present building, utilizing the existing column spacing, the use of a central control room was deemed impractical and the existing methods of arrangement and control were utilized. The electrical control was installed in the existing electrical control room that overlooks the turbine room on the switch-house side. The turbine controls and instrumentation was located in recessed panels on the boiler feed pump side of the turbine room as is the case with the existing units. The feedwater cycle controls were placed on a panel in the boiler feed pump bay which is a general extension. The main boiler panel and controls are located on the boiler operating floor and directly underneath the coal bunkers. A single panel is used for the two boilers. Operating positions and class of personnel will be exactly duplicated on this unit so as to conform with No. 3 and N. 4 Units.

Although the control of the unit is not unlike the present arrangement, the unit is essentially a plant in itself. Since the existing units are (No. 1 and No. 2) 600 psig, 725 F/725 F reheat and (No. 3 and N. 4) 650 psig, 900 F, the higher pressure of Unit No. 5 made it desirable to maintain no physical ties with the old units. This isolation is also carried out electrically so that all auxiliaries are carried by either one of two transformers.

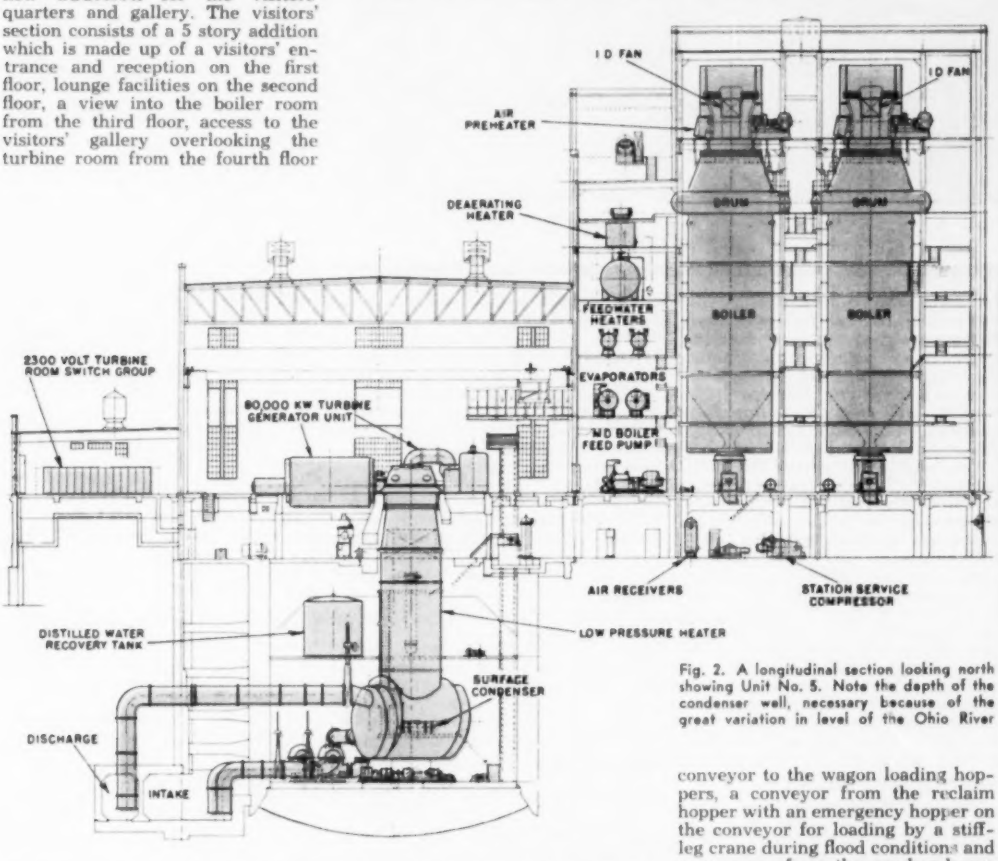


Fig. 2. A longitudinal section looking north showing Unit No. 5. Note the depth of the condenser well, necessary because of the great variation in level of the Ohio River

Coal and Ash Handling

All coal to the station is delivered by barge and handled by an existing river unloading tower. Facilities are also available for handling rail coal which is used very infrequently. The existing system is composed of a conveyor to the crusher house, a conveyor to the wagon loading hoppers, a conveyor from the reclaim hopper with an emergency hopper on the conveyor for loading by a stiff-leg crane during flood conditions and a conveyor from the crusher house to the building serving the first four units. Additions to the system for the 5th Unit are composed of a conveyor from the old crusher house to a new crusher house, a conveyor from a new reclaim hopper and a new 400 ton conveyor to the building. The reclaim hopper for this unit was set on a new coal pile area that has been raised above the existing coal storage areas to offer protection from floods. The coal that is stored on the high level area can be reclaimed for use on units No. 3, 4 and 5. A new tractor-wagon unit was purchased to handle the added coal for serving the station.

The coal bunkers are of the hopper type with a total capacity of 1100 tons. The filing slots are

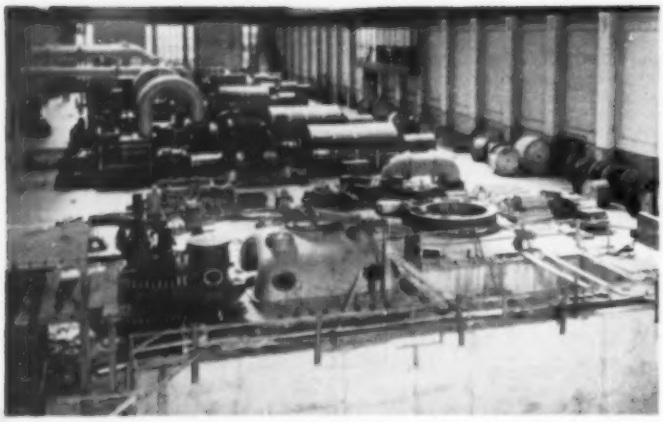


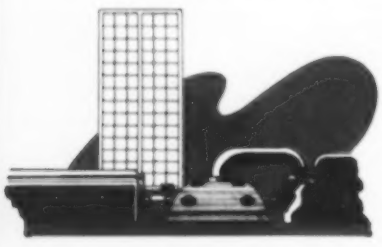
Fig. 3. A view in the turbine room of Miami Fort Station showing Unit 5 turbo-generator under construction

equipped with rubber zipper type self-sealing covers. Exhauster and dust recovery apparatus is installed to maintain a slight vacuum in the bunkers to hold down the outside dust to a minimum. For operators' comfort and safety, a completely automatic dust spray system is installed in all conveyors and crusher house to spray the coal at the spilling points. This system uses water and surface acting agents that have been proven adequate on other units.

The ash handling system is a 40-ton per hour hydraulic jet type supplied with two 1800 gpm ash sluice pumps pumping strained river water to two 8-inch jet propulsion pumps each located at the boiler ash hoppers. The ash is pumped through 8-inch "Durite" pipe through the building basement and XX-simplex pipe outside the building to an existing outside concentrating pit. Ash for all units is trucked from the existing pit to the fill areas located on the station property.

Boiler Plant

The unit is supplied by two Babcock & Wilcox water-cooled, dry bottom, radiant type boilers rated at 375,000 lb per hr continuous capacity with a maximum capacity of 410,000 lb per hr at 1300 psig, 960 F, at the superheater outlet. The unit is designed for a boiler efficiency of 86.8 per cent and comprises a water-cooled hopper bottom, radiant furnace, bent tube superheater, continuous tube economizer, and a Ljungstrom air preheater. The furnace is 31,830 cu ft with a heat release of 14,600 Btu per cu ft per hr. The furnace walls are "touching tube" with 3-in. tubes on 3-in. centers. The furnace roof is 3-in. on 6-in. centers, rear wall 4-in. on 8-in. centers. The boiler screen between the furnace and superheater is made up of the rear wall tubes fanned so as to make a four high bank of tubes spaced 12-in. centers and facing downward to the cool hopper bottom.



The main steam drum is 60 in. ID, 4-in. wall thickness and 30 ft, 4-in. long. It is equipped with B&W cyclone steam separators, each complete with individual moisture eliminator and directional discharge scoop. The cyclones are arranged so that all the steam and water mixture passes through the cyclones. Above the cyclones are additional B&W steam scrubbers.

The superheater is of the return bend continuous tube, self draining type having 24,195 sq ft of surface made up of 2½ in. tubes. The tube banks are made up of rows of Croloy 3-M, Croloy 2-M, Croloy 2, carbon moly and carbon steel. Since the entrance to the superheater is usually the most critical zone for ash and slag deposits, the tube spacing at this point is opened to eight inch lanes to reduce velocity with the flue gas temperature limited to 2,000 F. The superheater is designed to raise the steam temperature to 960 F from 250,000 to 410,000 lb per hr. Steam temperature control is attained by means of a set of dampers located at the top of the unit proportioning the gas flow across the superheater and economizer banks. The dampers are operated automatically by a Leeds & Northrup steam temperature control which uses the steam temperature thermocouple element in the main steam line as a sensitive device to control the 950 F temperature to plus or minus 10 F. The control incorporates combustion control impulses such as air flow differentials as an anticipatory function for temperature correction during load changes.

The economizer is of the continuous tube self-draining type having 10,397 sq ft of surface made up of 2½ in. carbon steel tubes. The tube spacing is such that the hottest gases pass through 8 rows with 8-inch spacing and 50 rows with 4-in. spacing. The gas flow is vertical with both parallel and counterflow of water.

Each boiler is equipped with a Ljungstrom air preheater directly above the unit, arranged so as to employ a minimum amount of duct work. The heater is arranged for upward flow of gases, and contains 79,900 sq ft of surface. The 56-in. depth of heating surface will be made in three layers, 32 in. deep at the intermediate layer and 12 in. deep at the cold ends. A single nozzle reciprocating steam soot blower is located on the air side driven by a ¼-hp electric motor, for maintaining a clean surface. A remote operated damper controlled by-pass around the heater is incorporated to maintain place temperatures of an order to keep fouling and corrosion at a minimum.

The soot blowers are Vulcan T-2 retractable units using 400 psig steam as the blowing medium with individual push button control at each blowing station. A study of the soot blowing requirements of the boilers resulted in a total of 4 blowers on each side of the unit. It was felt that some of these blowers would have to be blown very infrequently and on that basis individual push button control was selected over the automatic sequential control.

Each boiler is equipped with 4 Babcock & Wilcox multi-tip burners which are served by two B&W Type E-64 ball mills pulverizing 20,000 lb per hr of Ohio & West Virginia coal with a maximum of 10 per cent moisture, 45 grindability, to a fineness of 73 per cent through a 200 mesh screen.

The Sturtevant forced and induced draft fans are located in a completely enclosed room just above the boiler. The air preheater sets between the two fans and the arrangement makes a very compact job with very little ductwork. The induced draft fan exhausts into the existing stack serving the 4th Unit. The forced draft fan draws its air from a suction duct right above the boiler and furnace, removing the hot air at this point. The forced draft fan is equipped with inlet box and direct drive to a 400 hp motor. The induced draft fan is equipped with an American Blower Company hydraulic

coupling for automatic variable speed control, a double inlet with dampers and an erosion-resistant wheel with replaceable wearing pads.

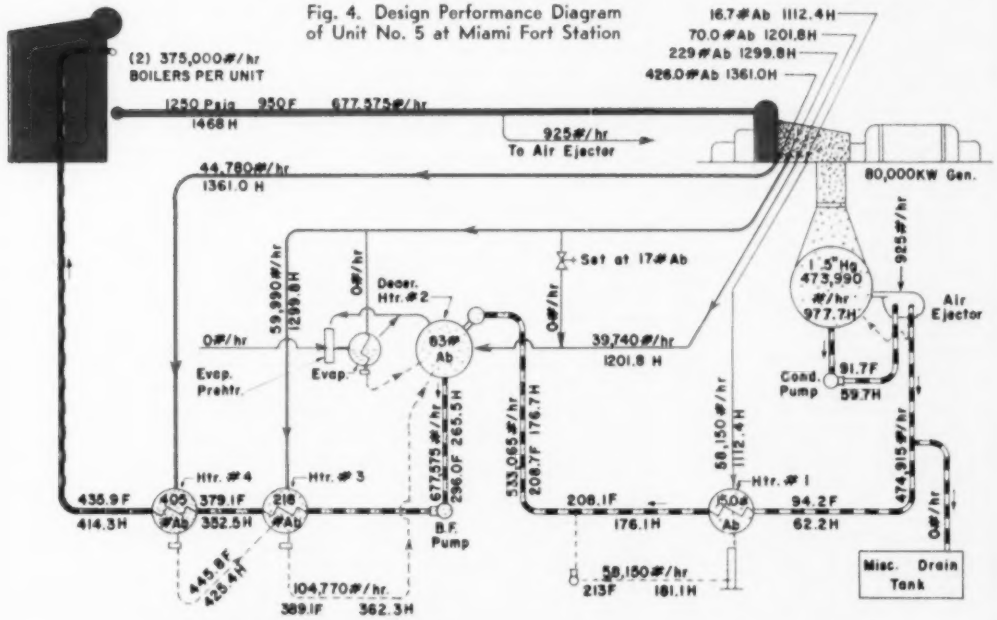
Feedwater Cycle

Four extraction feedwater heaters are incorporated in the design, as shown in the heat balance diagram, to heat the feedwater to a maximum of 460 F. Low pressure heater No. 1 takes steam from the 27th stage and is a straight tube heater installed vertically. The heater is equipped with a drain pump for pumping the drip back into the feed system. The No. 2 heater is a deaerating spray type heater operating off the 22nd stage bleed, having a sufficient storage for approximately 10 minute supply and equipped with stainless steel internals and adequate internal baffling to prevent vaporization at the boiler feed pump suction during sudden drop in load. The two high pressure heaters operating on the discharge are arranged horizontally, with straight tubes, taking steam from the 7th and 13th stages bleed points. The steam drip from the No. 3 high pressure heater normally cascades to the No. 4 heater through float controlled regulating valves or can be manually shifted to drain direct to the deaerating heater. The steam drip from the No. 4 high pressure heater normally discharges to the deaerating heater through a float controlled regulating valve. Provisions are made for emergency high water draining of these heaters, through float operated regulating valves, to the miscellaneous condensate drain tank, which in turn is pumped to the overhead distilled water storage tank or overflows to waste.

Liquid level control is not maintained at the condenser hot well, the condensate being pumped from the condenser hot well through the steam jet air ejector condensers, through the low pressure heaters to the spray jets in the deaerating heater heads. Surging and necessary make-up level control is handled by level controllers installed on the deaerating heater storage tank. Normal level changes allow water to flow from the overhead 25,000 gal distilled water tank to the condenser hot well through an automatic valve. Normal overflow in the storage tank is controlled to allow some condensate to flow to the overhead distilled water tank through automatic valves. This water flows from the condensate system at a point just before entering the low pressure heater and is comparatively cool. Overflow water from the overhead condensate tank is allowed to flow uncontrolled to the miscellaneous drain tank which in turn has an overflow to waste. The emergency overflow from the deaerating storage tank likewise flows to the miscellaneous drain tank but this is done through a float operated automatic valve. The miscellaneous drain tank located in the condenser well has a capacity of 25,000 gal and is equipped with two condensate drain pumps to transfer this water to the overhead tanks for miscellaneous drains. Condensate, which has been deaerated to 0.005 cc of oxygen per liter at a flow of 750,000 lb per hr, flows to the heater feed pumps located 60 ft below the deaerating heater.

The unit is served by three Ingersoll-Rand barrel-type 8-stage centrifugal pumps, each having a capacity of 450,000 lb per hr of 300 F feedwater when operating at 3570 rpm against a total dynamic head of 1610 psi. The pumps are of the latest design embodying construction that is expected to be effective in preventing corrosion-erosion of parts. The barrel casing is made of cast carbon steel; the shaft of "K" monel; shaft sleeves of chrome plated steel; impeller, casing wearing rings, diffusion vanes and packing glands of stainless steel. Each pump is direct connected to an Allis-Chalmers 1500 hp 3570 rpm, 3 phase, 2300 v motor arranged for across the line starting. For protection of the pump at low flow and no flow conditions a Republic by-pass control valve is installed to automatically discharge water through the

Fig. 4. Design Performance Diagram of Unit No. 5 at Miami Fort Station



Generator Output 80,000 kw

Turbine Steam Rate lb per kwh	8458	Gross Heat Rate, Btu per kwh	11,000
Turbine Heat Rate, Btu per kwh	8925	Operating Ratio, per cent	98
Boiler Efficiency, per cent	86.8	Plant Heat Rate, Btu per kwh	11,230
Auxiliary Power, per cent	6.5	Plant Thermal Eff. per cent	30.4

pump and back into the deaerating heater when the flow drops to approximately 100,000 lb per hr.

Make-up water for the unit is supplied by two evaporators of the submerged tube type, rated at 17,000 lb per hr each. The evaporators take steam from the 13th stage bleed which is the heater No. 3 position in the cycle. The coil drips are level controlled and flow to the main deaerating heater with provisions for emergency draining to the miscellaneous drain tank. The evaporators are served by a new hot process limesoda softener and deaerator which was installed with the unit and large enough to serve existing evaporators on the first four units. The softener receives clarified Ohio River water and after softening to one grain per gal hardness and filtered, sodium hexa-meta-phosphate is added to carry a slight PO_4 residual in the evaporators. It is expected that scaling of the evaporator surfaces will be eliminated.

Turbo-Generator and Auxiliaries

The Westinghouse 80,000 kw to 100,000 kw, 3600 rpm tandem-compound, double flow condensing unit is designed for 1250 psig, and 950 F,

Principal Equipment For Unit No. 5 Miami Fort Station

STEAM GENERATING COMPONENTS

2 Boilers, single drum, 375,000 lb per hr continuous, 410,000 lb per hr maximum, 1300 psig, 960 F at superheater outlet. **Radiant** furnace, tangent tubes, water cooled hopper bottom, furnace volume 31,830 cu ft, boiler and furnace 13,845 sq ft, return bend superheater 24,195 sq ft continuous tube economizer 10,397 sq ft, vertical fired multiple intertube burners—Babcock & Wilcox Co.

2 Ljungstrom regenerative air heaters, 79,900 sq ft—Air Preheater Corporation.

4 Pulverizers—Type E, 10.07 tons per hr, connected to 125 hp, 600 rpm, 2300 v motor—Babcock & Wilcox Co.

Steam soot blowers, retracting, 400 psig steam—Vulcan Soot Blower Corp.

2 Forced draft fan, Sturtevant Turbo Vane, 135,000 cfm at 11.0 in. H_2O, direct connected to 400 hp, 1150 rpm, 2300 v motor—Westinghouse Elec. Corp.

2 Induced draft fan, Sturtevant, 204,000 cfm at 11.2 in. H_2O, connected through a 36V8 American Blower hydraulic coupling to a 600 hp, 860 rpm, 2300 v motor—Westinghouse Elec. Corp.

Safety Valves—Manning, Maxwell & Moore, Inc.

Water columns—Diamond Power Specialty Corp.

Flues and ducts—American Boiler & Tank Co.

Hot process water softener—Worthington Pump & Mach. Corp.

TURBINE-GENERATOR AND HEATERS

1 Turbine-generator, 80,000 kw nominal, 100,000 kw maximum tandem-compound, double flow condensing, 1250 psig, 950 F and 1.5 in. hg. exhaust, connected to 100,000 kva, 3600 rpm, 3 phase, 60 cycle, 13,800 hydrogen cooled generator—Westinghouse Electric Corp.

1 Condenser, 2-pass, 60,000 sq ft welded steel shell, storage type deaerating hot well, 1-inch O.D. No 16 Bwg. arsenical copper tubes, 20-ft long—Worthington Pump & Mach. Corp.

1 Steam-jet ejector, twin 2-stage with inter and after condensers—Worthington Pump & Mach. Corp.

1 Low press heater, 27th stage bleed, 2520 sq ft, 175 psig water, vacuum to 50 psig steam, $\frac{5}{8}$-in. OD No 18 Bwg admiralty—American Locomotive Co.

1 Deaerating heater, 22nd stage bleed, direct-contact steam jet type 750,000 lb hr, 100 psig—Worthington Pump & Mach. Corp.

1 High pressure heater, 13th stage bleed, 3175 sq ft, 2100 psig water, 300 psig steam, $\frac{5}{8}$-in. OD No 15 Bwg copper nickel tubes—American Locomotive Co.

1 High Press heater, 7th stage bleed, 2510 sq ft, 2100 psig water, 600 psig steam, $\frac{5}{8}$-in. OD No 15 Bwg copper nickel tubes—American Locomotive Co.

2 Evaporators, submerged tube, 17,000 lb hr, 300 psig steam, 100 psig water—Foster-Wheeler Corp.

PUMPS

3 Boiler feed horizontal centrifugal, 8 stage, 450,000 lb per hr, 1610 psi, tdh, direct connected to 1500 hp, 3570 rpm, 2300 v motor—Ingersoll-Rand Co.

2 Circulating horizontal volute centrifugal, 34,500 fpm, 27 ft. tdh, direct connected to 300 hp, 200 rpm, 2300 v motor—Worthington Pump & Mach. Corp.

2 Condensate horizontal volute centrifugal, 1300 gpm, 380 ft tdh, direct connected to 200 hp, rpm 2300 v motor—Worthington Pump & Mach. Corp.

1 Service Water, double suction, single stage centrifugal, 2500 gpm, 270-ft tdh, connected to 250 hp, 1750 rpm, 2300 v motor—Allis-Chalmers Mfg. Co.

2 Heater drain, centrifugal, 180 gpm, 435 ft tdh—Worthington Pump & Mach. Corp.

2 Evaporator Feed, centrifugal, 225 gpm, 325 ft tdh—Allis-Chalmers Mfg. Co.

2 Condensate drain, centrifugal, 900 gpm, 160 ft tdh—Allis-Chalmers Mfg. Co.

2 Ignition Oil, cast iron Rotex, 4 gpm, 150 psig—Quimby Pump, H. K. Porter Company, Inc.

2 Treated Water, centrifugal, 300 gpm, 232 ft tdh—Ingersoll-Rand Co.

3 Chemical Feed, 6 gpm, 1550 psig—Milton Roy Co.

1 Deep Well Water, submersible pump and motor type, 5 stage 100 gpm, 250 ft tdh—Byron Jackson Co.

2 Ash Sluice, centrifugal, 1800 gpm 225 ft. tdh—Ingersoll-Rand Co.

4 Bilge Water, vertical centrifugal, 2 at 500 gpm, 90-ft tdh, 2 at 150 gpm, 40-ft tdh—Yoemans Brothers Co.

1 Oil transfer pump, Roper 2-in., 40 gpm—George Roper Corp.

COAL AND ASH HANDLING

Hoppers, grill, feeders, conveyors, chutes, tripper—Stephens-Adamson Mfg. Co.

Conveyor Belts—Cincinnati Rubber Co.

Coal Crusher—American Ring Type AC

Coal Bunker Sealing Zipper—Stephens-Adamson Mfg. Co.

Automatic Coal Scales—Richardson Scale Co.

Bunker Outlet Gates—Stock Engineering Co.

Tractor and Wagon Scraper—Construction Equipment Co.

Magnetic Separator—Dings Magnetic Separator Co.

Bunkers—Bethlehem Steel Co.

Ash Handling "Jet Propulsion"—United Conveyor Corp.

Ash Pipe, "Durite"—United Conveyor Corp.; American Cast Iron Pipe Co.

VALVES AND PIPING

Circulating Water Piping—Cast Iron—United States Pipe Foundry Co.

Main Steam, boiler feed and miscellaneous pipe—Pittsburgh Piping & Equip. Co.

Circulating Water Valves—Henry Pratt Co.; Chapman Valve Mfg. Co.

High Press. Steam Valves—Wm. Powell Co.

High Press. Water Valves—Lunkenheimer Co.

Feedwater Regulating Valves—Republic Flow Meters Co.

Miscellaneous Valves—Leslie Co., Crane Co., Edwards; Andale Valve Co.; American Car & Foundry Co.; The Cochrane Corp.; The Powers Regulator Co.; Fisher Governor Co.; Atwood & Morrill Co.; Chapman Valve Mfg. Co.

Strainers and traps—Yarnal-Waring Co.; Armstrong Machine Works; Henry Pratt Co.

Expansion Joints—Zallea Brothers.

Automatic Combustion Control—Bailey Meter Co.

Water Level Control-3 Element—Bailey Meter Co.

Superheat Temperature Control—Leeds & Northrup Co.

Boiler Meters—Bailey Meter Co.

Temperature Recorders—Leeds & Northrup Co.; Bailey Meter Co.

Conductivity Recorders—Leeds & Northrup Co.

Drum Level Indicators-Utiliscope—Diamond Power Specialty Co.

Level Indicators—Yarnal-Waring Co.

By-color gage glasses-boiler drums—Diamond Power Specialty Co.

Level Control Equipment—Fisher Governor Co.

Draft and Air Press. **Gages**—Ellison Draft Gage Co.

Pressure Gages—Manning, Maxwell & Moore

Industrial Thermometers—Palmer Thermometer Co.

Panel Boards—Bailey Meter Co.

Boiler Feed Pump re-circulating equip.—Republic Flow Meters Co.

ELECTRICAL EQUIPMENT

Generator bus, isolated phase bus structure, associated compartments for potential transformers, surge protectors, auxiliary transformer tap-off, 500 amp, 13.8 kv—The I-T-E Circuit Breaker Co.

3 Main power transformer, forced oil-cooled plus forced water-cooled, 33,333 kva, 13.2-76.2/132Y kv, connected delta-wye with grounded neutral—General Electric Co.

2 Auxiliary transformer, oil immersed, self-cooled, 7500 kva, 13.2-2.4 kv—Allis-Chalmers Mfg. Co.

2 440-v transformers, Dry, 500 kva—Wagner Electric Co.

Metal Clad Switchgear, 5 kv—The I-T-E Circuit Breaker Co.

440 v Switchgear—The I-T-E Circuit Breaker Co.

110 v Control Supply—The Powerlite Switchboard Co.

Lighting Supply—The I-T-E Circuit Breaker Co.

Motor Control Centers—Cutler-Hammer, Inc.

2300 v and 440v motors—Allis-Chalmers Mfg. Co.

Main Control Board—General Electric Co.

Main Generator Circuit Breaker—Westinghouse Electric Corp.

17 kv Cable, paper and lead—The Okonite-Callender Cable Co.

4.5 kv Cable, varnish cambric and lead—The Okonite-Callender Cable Co.

2.5 kv Cable—Simplex Wire & Cable Co.

600 v Cable—Simplex Wire and Cable Co.

MISCELLANEOUS

Pipe and tank insulation—Philip Carey Co.

Oil and Water Tanks—Stacey Bros. Gas Const. Co.

Elevator—Boiler Room & Condenser Pit—Warner Elevator Mfg. Co.

Elevator—Visitors Gallery—Shepard Elevator Co.

Air Conditioning and Ventilating Apparatus—Buffalo Forge Co.

Travelling Screens, Basket Type—The Chain Belt Co.

Control Air Compressors, non-lubricated—Ingersoll-Rand Co.

Service Air Compressor, 2 stage—Worthington Pump & Mach. Corp.

Turbine oil purifying equipment—De-Laval Separator Co.

Deepwell—Layne Ohio Co.

Vent Fans—H. H. Robertson Co.; C. G. Breidert

Hoists—Shepard-Niles

CONSTRUCTION

Supervision—The Cincinnati Gas & Electric Co.

Designers—Sargent & Lundy

Structural Steel—The Bethlehem Steel Co.

Structural Contractor—The Ferro Concrete Const. Co.

Boiler Erection—The Babcock & Wilcox Co.

General Equipment Erection—Oberle-Jordre Co.

Electrical Installation—Bertke Electric Co.

steam conditions. The last stage blades are 23 in. long, the longest presently being used on 3600 rpm. machines. The unit has two throttle valves and four extraction openings. The hydrogen cooled generator has a double rating of 80,000 kw, 0.8 power factor and 100,000 kw, 0.87 power factor at 0.5 psig and 15 psig respectively. The field current is supplied by shaft-driven main and pilot exciters with automatic voltage control. Reserve excitation is available from an excitation bus supplied by motor generators.

The generator is connected directly to the main 100,000 kva, 13.2 kv, delta to 132 kv grounded wye step-up transformer bank. This connection is provided by metal enclosed isolated phase bus duct rated 5000 amp at 15,000 v. Taps are provided for generator surge protection, potential transformers and the high voltage connections to the 7500 kva, 13,200 volt to 2400 v auxiliary power transformer. The current transformers for differential protection and meters are in the bus duct housing. The isolated phase ducts have 2 foot diameter aluminum casings or housings encompassing the bus.

The buses are hollow squares of copper, 7-in. on the side and ½ in. thick, rated at 5000 amp and carried overhead where they are free from flood hazards. There are no circuit breakers between the generator and connections to the bank are made in ducts supported over the trans-neutral is grounded through a transformer with a resistor in the secondary which in combination with the protective capacitors limits ground current. The total generator output supplies the system through the 132 kv. switch-yard which lies adjacent to the plant.

Fig. 5. Reinforced concrete condenser well, 70 ft inside diameter. This well is sunk to 415 ft which is 96 ft below the turbine room floor

Power for the unit auxiliaries is normally supplied directly from the generator leads through the 7500 kva, 3-phase, 60-cycle, 13,200/2400-v transformer and a spare 7500 kva auxiliary transformer fed from the existing 13,200 v bus in the station. Motors rated at 50 to 1500 hp are supplied at 2400 v; those between 1 and 50 hp at 440 v. All fractional horsepower motors are supplied by a 110-v, 3 phase supply.

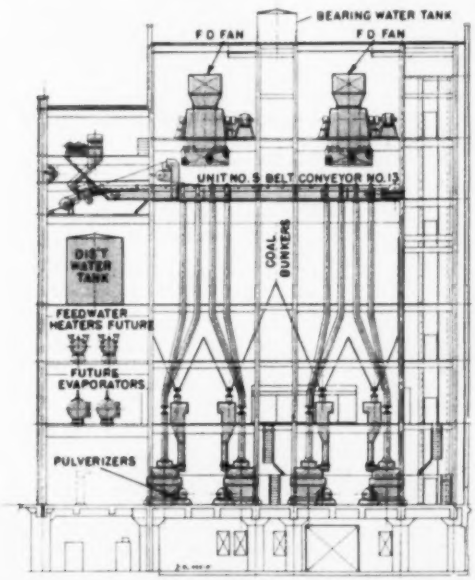


Fig. 6. Elevation of the end of the boiler room showing the arrangement of the coal handling equipment for the two new 410,000 lb per hr steam generator

VAPOR LUBRICATION FOR SLIDING CONTACTS

ELECTRIC CONTACTS or "brushes," made of graphite and used to feed current to moving parts in motors or generators on high-altitude aircraft, may have their useful life increased many thousands of times as the result of new lubrication methods devised by Robert H. Savage, in the General Electric Research Laboratory.

His discovery about water, in the form of vapor, for the lubrication of graphite has changed accepted ideas that this solid and "slippery" material was a good lubricant in itself. Graphite consists of layers of atoms which can slide easily over each other, and it was formerly supposed that this property was inherent in the graphite alone.

He has shown, however, that an invisibly thin film of moisture on graphite is required for its lubrication. Testing the wear against a revolving copper disk in a vacuum chamber, he found that dry graphite brushes were worn as fast as an inch within one hour. When a small amount of water vapor was admitted to the chamber, the wear rate was reduced to less than a thousandth as much.

Further developments are now being carried on, to apply the findings to actual aircraft where the wide range of operating conditions impose some problems that have yet to be solved.

Bus Transfer Tests on 2300-v Auxiliary System

An account of a series of tests made at the Phillips Plant of the Dequesne Light Company to determine the optimum time interval between the opening of one breaker and the closing of the other for bus transfer. Oscillographic records were made to show the effect on the various station auxiliaries

GOOD STEAM power plant practice requires that at least two sources of power be available from which the auxiliaries may be supplied. In the event of failure of one source, the load can be transferred to the other.

The manner in which this transfer is made affects the auxiliary feeder circuit breakers and other equipment in the station. To determine how the equipment on the system behaves under the transfer from one auxiliary system to the other, a series of interesting tests were made recently at the Phillips Power Plant of the Dequesne Light Co. The results of these tests were presented in a paper by A. A. Johnson of Westinghouse Electric Corp. and H. A. Thompson of the Dequesne Light Co. before the winter meeting of the AIEE.

Description of Test System

The Phillips Plant has one 75-000-kva turbo generator with a 7500-kva, 2300-v, 3600-rpm auxiliary generator on the same shaft with the main unit. The auxiliaries shown schematically in Fig. 2 are divided into two major groups, and either group may be supplied from the auxiliary generator or from a 7500-kva station service transformer. The auxiliary system includes all of the large motors for boiler and turbine service, the 440-v power and station lighting. Normally one bus is connected to the station service transformer, and one to the auxiliary generator. Voltage transfer equipment is provided between these two main sources. If the power source feeding one of the buses fails, that source is disconnected automatically and the circuit breaker to the other source is closed automatically. At no time are the two sources of power paralleled because the air circuit breakers on the auxiliary system were not installed to handle simultaneously the short circuit kva from both sources. In addition, the two sources may not be in phase and large circulating currents may be present if both are closed at the same time. During start-up of the station, both auxiliary buses 1-A and 1-B are supplied from the station service transformer. After the main unit is synchronized to the system, one of the auxiliary bus sections, usually 1-B, is transferred by "open transition" to the auxiliary generator.

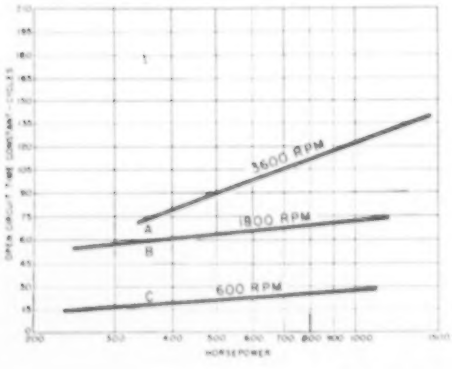


Fig. 1. Typical time constants for 2300-v squirrel cage induction motors

Test Objectives

The tests were to determine the optimum time interval between the opening of one breaker and the closing of the other breaker for a bus transfer. It is difficult to determine the optimum time interval except by actual test since an induction motor or a group of induction motors, when disconnected from their source, will continue to generate a voltage for some period of time. The period of time required

for this voltage to decrease to substantially zero will vary depending upon the size, speed, and load on the motors. Figure 1 gives the typical open circuit time constants of typical motors. If the transition time is too short, the residual voltage on the motors which can be 180 deg out of phase with the other source may cause excessive currents to flow in the motor windings when they are connected to the other source. If the transition time is long, other detrimental effects may be encountered in the station which will be discussed later.

Test records were also obtained on the operation of the automatic voltage regulator in the field circuit of the auxiliary generator when a bus was suddenly transferred to the generator. The recovery of the generator voltage depends on the action

of the regulator which, in turn, is affected by the time for the various motors to come back to normal speed and power consumption.

Test Outline

The set-up in the power plant is such that the speed at which a voltage transfer operation may be accomplished can be varied from a minimum of about 10 cycles up to several seconds. The longest transfer time is limited by the deceleration time of the circulating water pumps, whose discharge valves must be closed in the event voltage is removed for several seconds to prevent them from reversing. The circulating water pump may reverse if it is deenergized very long because the other circulating water pump will force water through the first one instead of through the condenser. To obtain test results for three time intervals, it was planned that transfers could be and would be made in about 10, 75, and 150 cycles.

It was desired to get as much information as could be obtained on three oscillographs operating simultaneously. In addition to obtaining current to the large motors and the total bus current, power measurements were made for more complete information. The following simultaneous oscillograph records were obtained:

CURRENTS	POWER
Total to Bus 1-B	Total to Bus 1-B
Boiler Feed Pump	Boiler Feed Pump
Circulating Water Pump	Circulating Water Pump
Mill Motor	
Forced Draft Motor	VOLTAGES
Induced Draft Motor	Generator
Generator Field	Bus 1-B

The total current to Bus 1-B was obtained by paralleling the secondaries of the current transformers from the auxiliary generator and the service transformer so that when the bus was transferred, the current changed from one source to the other on the same record.

The first part of the tests covered four transfers of Bus 1-B from the generator to the transformer and back to the generator. During these tests the load on Bus 1-A was supplied from the transformer. Measurements were also made on tests involving three transfers of Bus 1-B from the transformer to the generator with Bus 1-A being supplied from the generator.

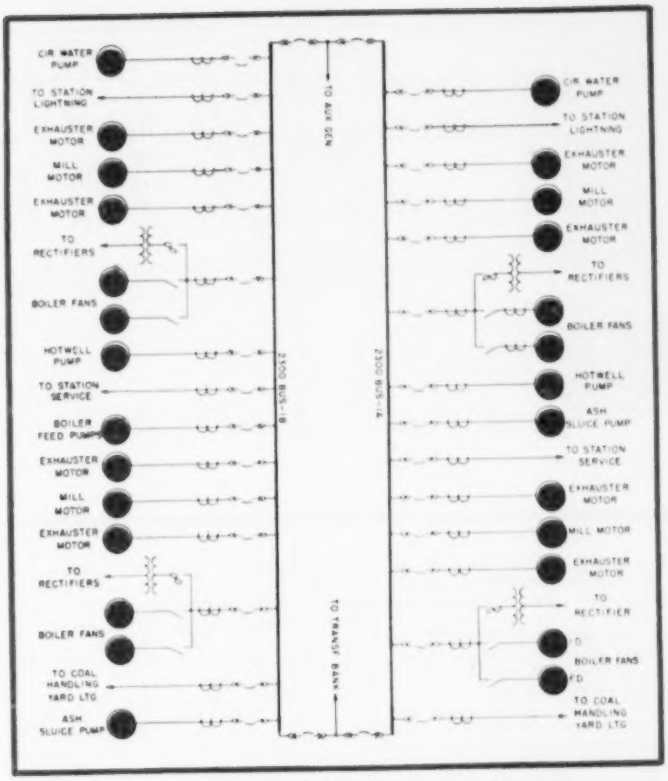


Fig. 2. Schematic diagram of the auxiliary system at Phillips Plant

Bus 1-B Motors

The load on Bus 1-B of this auxiliary system during the tests consisted of about 2500 kw made up of the following 2300-v motors:

Motors	No. Units	Motor HP	Per Unit Pull Out Torque	Sync. Speed
Boiler Feed Pump	1	1250	2.38	3600
Forced Draft Fans	2	200	—	1200
Induced Draft Fans	2	400	2.30	900
Pulverizer Mills	2	250	3.15	900
Pulverizer Exhausters	4	75	—	1200
Circulating Water Pump	1	500	3.14	450
Hotwell Pump	1	125	—	1200

Test Results

Typical Oscillograms—Figure 3 is an oscillographic record of generator voltage, bus 1-B voltage, total current, and total power before, during and after an 11-cycle transfer from the transformer to the generator. The generator field current is also shown. It will be noted from this record that bus 1-B voltage decreased during the time the source was disconnected. At the instant of closing the breaker to the generator, the first half cycle of total bus current is more than double the maximum half cycle of the current which follows. This is due apparently to a readjustment of flux conditions in the motor, and after a few cycles the motors take the normal current for their speed and load conditions. Figure 3 also shows that the average field current to the

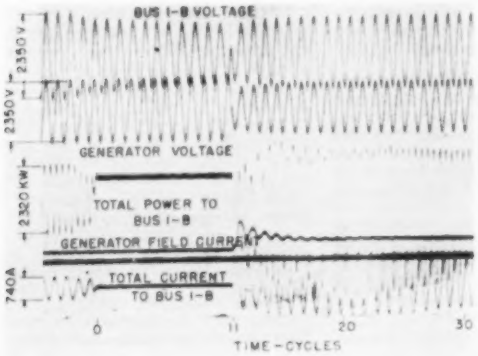


Fig. 3. Oscillographic record for transfer interval of 11 cycles for total load on Bus 1-B. Transfer from service transformer to auxiliary generator

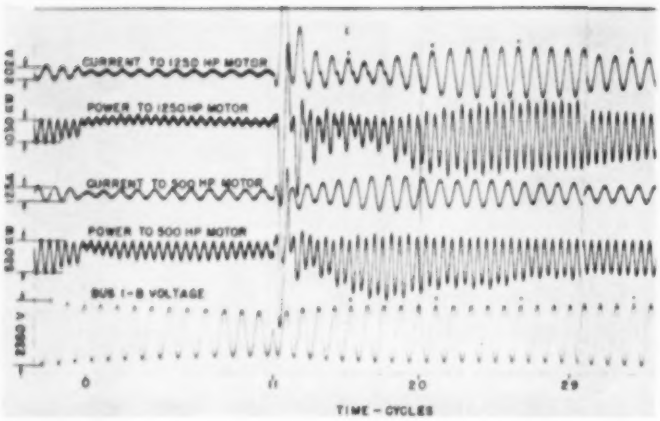


Fig. 4. Oscillographic record for transfer interval of 11 cycles for boiler feed pump motor and circulating water pump motor

generator about doubled in less than one cycle. Figure 4 is an oscillographic record of the current and power to the 1250-hp boiler feed pump motor, and the 500-hp circulating water pump motor for a similar transfer time. The boiler feed pump acts as a generator when the source is disconnected, and supplies power to other motors connected to the bus. (The power record on these motors is not the true total power because the measurements were made using a line-to-line voltage and a single-phase current which lagged the voltage by 30 deg plus the power factor angle.)

Maximum RMS Inrush Current—The points shown on Fig 5 are the values of RMS current for the maximum half cycle to bus 1-B plotted against the transfer time interval. The curve on this figure is a calculated curve based on the total maximum half cycle of RMS inrush current for all of the motors on bus 1-B. This curve includes the effect of residual voltage on the bus and the impedances of the generator source. It was assumed that the residual voltage on the bus was 180 deg out of phase with the source to which it was connected. All of the total measured currents were less than the calculated currents. The calculated currents, however, include full displacement of the RMS current wave. Since the current was measured on only one phase for each test, the probability of obtaining a fully displaced wave was greatly reduced, but most of the current values are within a ratio of 1.6 or less of the calculated curve.

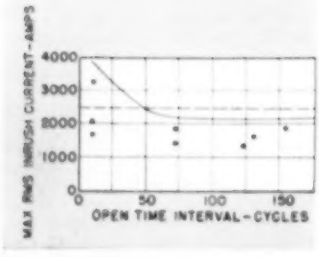


Fig. 5. Maximum RMS inrush current to Bus 1-B versus open time interval in Cycles. Points obtained from tests. Curve is theoretical maximum

The inrush currents to the 1250-hp boiler feed pump are shown in Figure 6. The points represent measured values, and the solid curve was calculated in a manner similar to that for the total current. The dashed line shows the maximum inrush current which the motor is designed to withstand mechanically. Thus it is clear that the time interval for safety to the bracings in the motor windings should be a minimum of about 50 cycles. Similar results were obtained for the other four motors on which measurements were taken. The results also apply to all motors on the auxiliary bus.

Residual Voltage on Motors—The residual voltage on this group of motors versus time is shown on Fig 7. This record incorporates the effects of the "open transition" time constants of the various motors as well as the decrease in speed due to motor loads.

The time required for the residual voltage on the bus to reach a phase position of 180 deg with respect to the source voltage was 12 to 13 cycles. Thus a transfer time interval or 12 to 13 cycles would cause maximum inrush current to the motors. In about 20 cycles of open time the residual voltage would be back in phase after one slip cycle with the source voltage. In one test with a time interval of about 22 cycles, the maximum inrush current to the motors was materially reduced.

Time to Regain Normalcy—The time for the various motors to regain normal operation after being reconnected to a source is shown in Fig 8. This time is plotted against the open time interval. The curves show the relative order in which the motors are restored to normal operating conditions. The 1250-hp boiler feed pump motor takes the longest time, and the fan motors take the least due to the torque limiting action of the magnetic coupler control.

The fan motors are connected to the fans through magnetic couplers. The field current to the couplers is taken from the supply to the fan motor through an electronic rectifier. The control on the rectifier is such that when full-load motor current is exceeded the field current is reduced and slip in the magnetic coupler increases. Thus with this type of control the fan motors will accelerate quickly after a transfer because the motor is essentially unloaded.

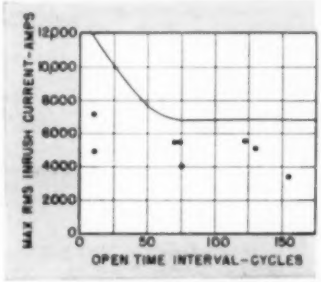


Fig. 6. Maximum RMS inrush current to boiler feed pump motor (1250 hp). Points obtained from tests. Solid curve is theoretical maximum. The dashed curve is the maximum current for which the motor is designed

Voltage Disturbances — The greatest dip in voltage occurred for the fastest transfers. The generator voltage dropped to about 65 per cent of normal following an open time interval of 11 cycles, but recovered in about 60 cycles total time. For a time interval of 75 cycles, the generator voltage dropped to about 75 per cent of normal, but required a much longer total time of about 200 cycles to recover. For longer time intervals the voltage still dropped to about 75 per cent of normal, but took even longer to regain normal operation.

Auxiliary Generator Voltage Regulator—The generator voltage regulator operated satisfactorily for

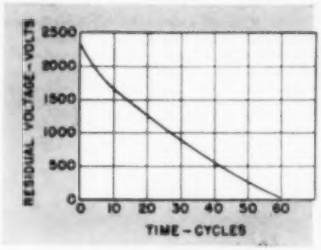


Fig. 7. Residual voltage versus time for all motors connected to Bus 1-B

every test. The time for the regulator to take action was less than one cycle as shown on the oscillographic records given in Fig 3 and 5. In each case when bus 1-B, which has a load of about 2500 kw, was transferred to the generator, the average field current increased about 100 per cent and stayed at a high value until the voltage on the generator terminals regained its normal operating value.

Boiler Operation — In every transfer test, up to a time interval of 150 cycles, the coal pulverizer mill motors and fan motors obviously decreased in speed; however, this decrease in speed had no noticeable effect on the fires in the boilers, nor was there any evidence of unsatisfactory operation of the boilers. The pulverizer mills were the ball mill Hardinge type and gave no evidence of stalling or unnecessarily increasing the duty on the motor when it was connected to the new source.

General Discussion

Tests which were limited to a maximum of 150 cycles had satisfactory motor transfers except that the circulating water pump was lost on one test. One period of time developed to be about 300 cycles, and many of the auxiliary motors were shut down by protective relays. Without question, this time of transfer is entirely too long, and in fact 150 cycles is also entirely too long. The preferred time interval should be when the residual voltage approaches zero, or for this system about 50 cycles.

During the transfer tests the station lighting and the 400-v power equipment were connected to another source so they would not be affected. The control room fluorescent lighting was placed on another source because if the voltage is removed, the lights will go out and require several seconds to relight. The flickering of these lights on return of voltage would have been disturbing during the test periods. Under normal operating conditions this factor may not loom large in the over-all considerations of how auxiliaries should be transferred, but should be considered and additional lighting made available from some other source.

Conclusions

(1) For this auxiliary system the optimum transfer time interval is about 50 cycles. This transfer time assures greater mechanical safety to the motor windings than if a shorter transfer interval were used.

(2) For transfers made in approximately 10 to 15 cycles, abnormally high motor currents may flow. This is caused by the fact that the residual voltage on the bus is still about 75 per cent of normal and is about 180 deg out of phase with the new source voltage. This condition may cause a current considerably in excess of that for which the motor was designed mechanically.

(3) The transfer of auxiliary bus sections by "open transition" can be safely accomplished. For any auxiliary system the preferred open time interval is determined by the time required for the residual voltage to decay to approximately zero. The actual time should correspond to no less than that which gives an inrush current to the motors equal to or less than the fully offset current which each motor would take when starting across the line from an infinite source at its terminals.

(4) Automatic "open transition" transfers should be controlled by devices which give an accurate fixed

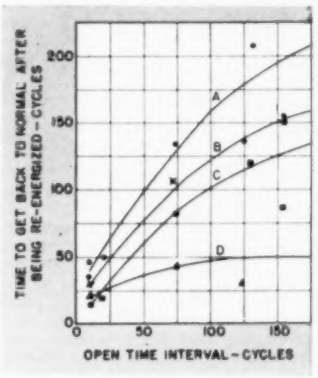


Fig. 8. Time for motors to regain normalcy
A—Boiler feed pump motor
B—Pulverizer mill motor
C—Circulating water pump motor
D—Forced and induced draft fan motor

open time interval. Such a device would insure that the inrush currents were not excessive, and also that the reclosing would not be delayed unnecessarily.

(5) After the residual voltage has decreased to zero, the maximum inrush current to each motor is substantially the same for any time interval. The longer the open time interval, however, the longer it takes the motors to accelerate back to normal operating speed.

(6) Delaying the transfers to the required 50 cycles will probably extinguish fluorescent lighting, but emergency lighting should assure that no area will be in darkness. The fluorescent lighting re-establishes itself when the bus is connected to the new source, but the flicker may be somewhat disturbing.

(7) During the time residual voltage exists on the bus, the boiler feed pump motor supplies power to other motors. This has the effect of reducing the residual voltage faster. Other motors may also serve as generators during the time residual voltage exists if they have enough stored energy in the rotating parts.

(8) When the load is transferred to the auxiliary generator, the voltage regulator must function to limit the voltage drop and to restore the voltage to normal.

(9) The coal pulverizers operated satisfactorily for all transfer time intervals up to 150 cycles.

(10) For all tests of 150 cycles or less, there was no noticeable effect on the normal operation of the station boilers.

BOILERS FOR EUROPEAN INDUSTRIES SUPPLIED BY B & W UNDER MARSHALL PLAN

Boilers for essential industries in five countries under the Marshall Plan are being supplied by The Babcock & Wilcox Co. Public utilities in France, Denmark, Greece and Italy, and a process plant in Iceland will use the 14 boilers now in various stages of construction or installation. A total of 655,000 kw will be added to the generating capacity of Europe's utility plants.

In France, an outstanding example of rehabilitation is that of the Gennevilliers plant, the largest power station, not only in France, but in all Continental Europe.

Three complete boilers and some major components for three more were furnished for this plant by B&W. The remainder were fabricated in France by the Societé Francaise des Constructions de Babcock & Wilcox, a French affiliate.

These boilers will permit the station to generate on additional 200,000 kw above its present output.

One of the largest, if not the largest boiler in Europe, will go into an extension of the Arrighi Power Station at Paris. With a steam capacity approximately 1,000,000 lb per hr, it will add 100,000 kw to the output of this station.

In Denmark, the Isefjord Power Company has ordered two Radiant boilers for an addition to the Kyndby Power Station situated on the Island of Suaelland near Copenhagen. With an individual capacity of 575,000 lb of steam per hour, the two boilers will help to generate 120,000 kw.

In Greece, the Athens Piraeus Electricity Co., Ltd., will install two 125,000-lb-per-hr boilers of the two-drum Stirling type at the New Phaleron Power Station.

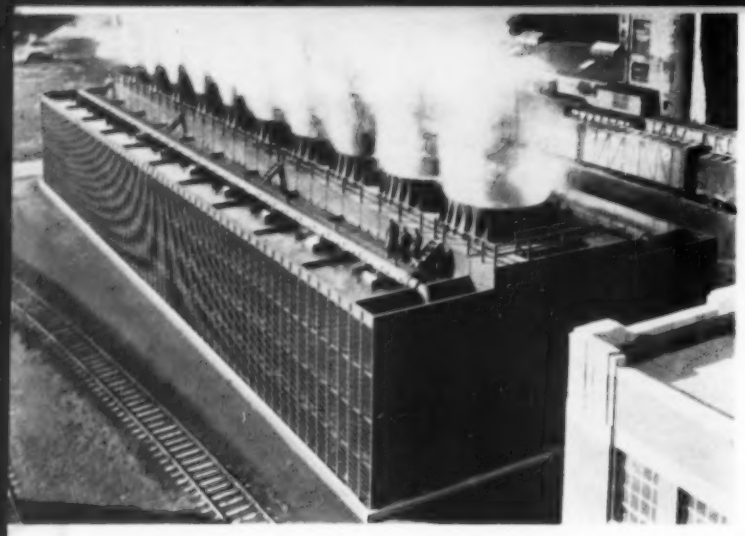


Fig. 1. View of a large 10-cell double-flow induced-draft cooling tower installed at a distillery. Shows the central induced-draft fans, cross-flow air inlet louvers, open water distribution basin at top, inspection and maintenance walk-ways, water distribution headers

By **HOWARD E. DEGLER**
Technical Director
The Marley Co., Inc.

Water-Cooling Towers

How They Are Built, How They Work,

ALL POWER ENGINEERS are familiar with the procedure in which cooling or circulating water picks up rejected heat in a steam turbine condenser, a Diesel cylinder water jacket and so on; and how, by having this heat in turn transferred to the atmosphere, the circulating water can be cooled and used over again. This is done when there is not an inexhaustible, free-flowing cooling water supply; or, in some cases where waste of circulating water is prohibited; and sometimes when the water contains dissolved salts that might scale up the heat exchanger apparatus.

This saving and controlling of circulating water is usually carried out by the familiar spray ponds and water-cooling towers employed in steam power plants, refrigeration plants, Diesel engine plants and air conditioning plants. Other types of atmospheric heat transfer devices, like the evaporative condenser and the radiator type exchanger, will not be discussed here.

The accompanying illustrations show how the common forms of cooling towers are built and the principles on which they operate.

How Cooling Towers Work

Water, when cooled by the evaporative effect, transfers to the air approximately 1000 Btu per pound of water evaporated. The heat contained in the water vapor thus produced is known as the latent heat of vaporization. Air, absorbing heat from water in this manner, is capable of cooling the water below the atmospheric (dry-bulb) temperature. This distinctive fact permits water cooled by the evaporative method to serve applications having a great variety of temperature requirements, and it also enables a small volume of water to dispose of a much greater heat load than would otherwise be possible.

In a water-cooling tower, as the water falls from level to level, down through the wood filling, Fig. 3, it splashes into fine droplets and spreads out over the wood laths in thin films, thus providing the utmost exposure of water surface to the upward-moving air. The rate of heat transfer by convection and evaporation, hence the water-cooling effect, will be accelerated by: (1) increasing the velocity of air passing over the exposed water surface; (2) increasing the surface area of the water being exposed to the passing air; (3) lowering the atmospheric pressure (increasing elevation above sea level); (4) raising the entering water temperature; and (5) reducing the water-vapor content (humidity) of the air.

The physical properties of air most important to waste-heat disposal with evaporative water-cooling equipment are: wet-bulb temperature, dry-bulb temperature, humidity, total heat in Btu, pressure, weight and velocity.

The wet-bulb temperature of air is usually obtained by whirling a wetted thermometer-bulb in the air until a consistent reading is obtained. Total heat (latent plus sensible) of the air may be determined from its wet-bulb temperature. See Table II. Theoretically, water can be cooled by the evaporative method until its temperature is lowered to the air's wet-bulb temperature. In practice, however, water is cooled to a temperature approaching the wet-bulb. The closer this approach the larger the size of the cooling equipment required for a given duty.

As defined previously, the cooling range, Fig. 4, is the degrees F dif-

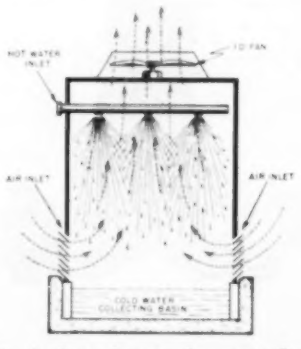


Fig. 2. Basic elements of a counterflow water-cooling tower, water—black, air—red

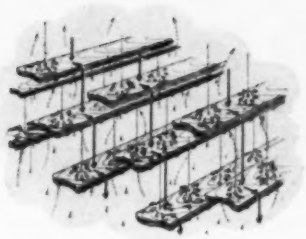


Fig. 3. Basic principle of counterflow cooling tower; air moves across water drops and film surfaces, lowering water temperature by convection and evaporation

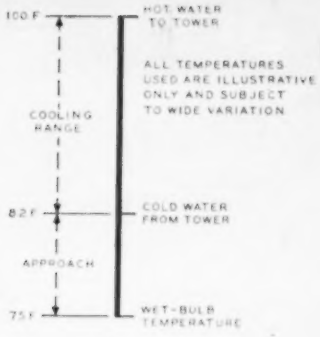


Fig. 4. Diagram showing definition of "Cooling Range" and "Approach"

How to Operate and Maintain Them

ference between the temperature of the hot water entering the cooling tower and the temperature of the cold water leaving the tower. The cooling range may be determined by dividing the total heat to be dissipated in Btu by the pounds of cooling water circulated thus:

$$\text{Range} = \frac{\text{Btu per min heat load}}{\text{gpm} \times 8.33 \text{ lb per gal}}$$

This equation indicates that, for a given heat disposal problem, the cooling range can be made any desired amount by increasing or decreasing the quantity of water circulated.

Types and Construction

Type of water-cooling equipment used affects to a considerable extent the operating temperatures of the cooling water. Some types of equipment such as spray ponds, natural-draft spray towers, and natural-draft deck towers that depend upon prevailing winds for cooling the water, must be built for low wind-velocity conditions. Such equipment is not capable of maintaining a close approach to the wet-bulb air temperature, and correlated allowances must be made for good operation at all times under widely varying conditions. On the other hand, where mechanical draft equipment is employed (to produce air movement) under similar conditions, lower average operating temperatures can be obtained since a dependable approach to the wet-bulb is practicable.

Spray Ponds

Spray ponds, Fig. 6, are recommended only for large-capacity services where high efficiency in a limited area is not demanded and drift moisture is not objectionable. They are inexpensive and entirely satisfactory when correctly applied, although pumping requirements and basin costs are generally disproportionate with modern induced-draft cooling towers.

Natural Draft Cooling Towers

For water-cooling requirements of less than 30,000 Btu per min, the spray-filled natural-draft tower, Fig. 7, is satisfactory. (The word "tower" is a misnomer, for the design simulates a narrow spray pond —length twice or more the width— with elevated nozzles and a high louver fence.)

Drift is considerably less in a properly-designed natural-draft tower than in the spray pond, but the drift nuisance may be considerable; for this reason natural-draft towers are unsuitable for downtown building roofs, locations adjacent to buildings, or near expensive mechanical equipment in industrial plants. They must be located in an open area, broadside to the prevailing wind, and are inefficient with less than 3mph wind velocity and wind directions other than broadside. These towers are generally unattractive and since they are long and high for their width, must be securely anchored to prevent uplift or overturning during high winds. High pumping requirements and total dependence upon atmospheric caprice, especially wind (quantity and direction), are disadvantages.

Mechanical Draft Towers

The mechanical-draft tower consists usually of a vertical shell constructed of wood, metal, transite, or masonry, in which water is distributed near the top uniformly over the area, and falls to the collecting basin in the bottom, passing through air which is being circulated in the tower from bottom to top by forced or induced draft fans, or horizontally in cross-flow towers, by induced-draft fans. The air is in contact with the hottest water just before leaving the tower; hence a given quantity of air picks up more heat than the average equal quantity of air on natural-draft equipment. This permits the water to be cooled with the least quantity of air required by any type of cooling equipment. As movement of air through the towers is obtained by power-consuming fans, it is essential that this air quantity and pressure drop be reduced to a minimum so as to secure low operating cost.

The inside of a mechanical draft tower may be spray filled or it may

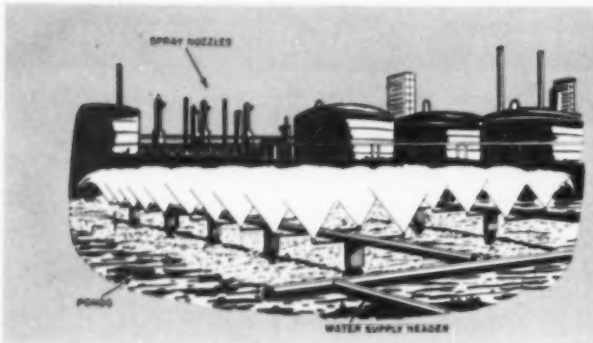


Fig. 5. Spray pond usually consists of water-collecting basin, above which nozzles spray water upward into air

Properly-designed nozzles break up water into small drops but not mist. Objective is to cool pond water, hence individual drops must be heavy enough to fall into pond, not drift away. Water surface exposed to air passing over pond is total area of all small drops. Louver fences required for all roof locations and for restricted ground locations

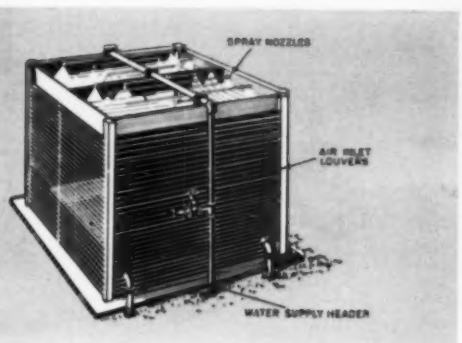


Fig. 6. Spray-filled natural draft tower

Nozzles usually spray down; center of nozzle system usually not more than half distance of nozzles above basin. Tower heights from 6 to 15 ft; total width not greater than height. Loadings from 1 to 2 gpm per sq ft tower area; hence area required about ⅛ area of equivalent spray pond. Continuously wet louvers add to exposed water surface

be packed with wood filling over which the water cascades from top to bottom. In many cases, a combination of the two is used, as in Fig. 7.

The net, free cross-sectional area of the air spaces in a spray-filled tower is greater than that of the wood-filled tower for the same plan area. However, the pressure drop is less and the air velocities higher with a shorter time of contact between air and water in the same size structure for a spray-filled tower. Before discharging to the open atmosphere, the water-laden exhaust air passes through a drift eliminator to remove entrained unevaporated water.

Performance of mechanical-draft towers is independent of wind velocity, hence it is possible to design them for more exacting performance. They require less space and less piping than atmospheric deck towers, and the pumping head varies from 11 to 30 ft, depending upon the design. Over-all plant economy due to colder water temperature usually more than offsets the additional operating expense and initial cost as compared to natural draft towers.

Forced-Draft Towers

The forced-draft type of water-cooling tower has one or more fans located in the air entering the tower and is suitable for corrosive waters; it has the fan mounted near the ground level on a rigid foundation where it is easily accessible. Operating costs are high because of high fan power requirements, and maintenance and depreciation both are high by modern standards.

Greatest objection to the forced draft tower design is that the heated air leaves the top of the tower at a low velocity and is subject to "recirculation" to the fan inlet; this action reduces the performance and could be as much as 20 per cent. During cold weather, recirculation may cause ice formation on adjacent equipment and buildings as well as in the tower fan ring. Their limited fan size (12 ft or less) means more fans, motors, starters, and wiring in larger capacities than are needed by induced-draft towers which can use fans as much as 20 ft in diameter.

Principal Types of Induced-Draft Towers

The counterflow (conventional) type of induced-draft tower has the fan located at the top, Fig. 7, to provide vertical air movement across the filling and discharge it upward at a high velocity to prevent recirculation. Another type (small requirements) has the induced-draft fan in one end, to provide horizontal flow.

During the past 10 years, desire for a more compact design, better construction, lower cost, larger capacity, more flexible operation, and improved all-around performance has led to the double-flow (also called cross-flow) induced-draft cooling tower, Fig. 8.

Operation and Maintenance

Water Treatment

Treatment of cooling tower water includes: prevention of corrosion and scale formation on heat-exchanger equipment; prevention and control of algae; control of delignification of cooling tower lumber. Injurious delignification of wood is seldom encountered in cooling tower operation.

Amount of make-up water required by a cooling tower depends upon evaporation loss, drift loss, and blow-down. Evaporation losses average 0.75 per cent of the water circulated for each 10 F range. Drift loss is the water carried from the tower by the air current in the form of droplets or mist. This loss approximates one-tenth of one per cent in properly designed induced draft towers; most cooling tower manufacturers will guarantee a drift loss not to exceed two-tenths of one per cent. Amount of blow-down water required depends upon hardness of circulating water, type of water softener or inhibitor used, and amount of drift loss. Blow-down is normally controlled to maintain the concentration of dissolved and scale-forming solids below the point where the formation of scale would occur or would be caused by corrosion.

Scale. Some scale-forming materials are found in practically all water, however, the most troublesome in water-cooling systems are normally calcium and magnesium carbonates and sulphates. Too high a concentration of dissolved solids in cooling-tower water will raise the effective wet-bulb temperature, which in turn raises the temperature of the water leaving the tower and may cause sludge or corrosion in the system. These dissolved solids also cause scale formation on equipment, thereby causing a reduction in the heat transfer rates.

Scale can be reduced materially, or prevented, by treating the make-up water by some softening process. The following methods for scale prevention may be used, however, the choice is largely one of an economic nature and since water treatment requires close regulation and control, a competent chemist should be consulted.

1. Use the lime softening process to remove carbonates.
2. Use hydrogen-replacing Zeolites which do not produce sodium bicarbonate or carbonate.
3. Use sodium Zeolite softening and add sufficient sulphuric acid, thereby converting the bicarbonates to sulphates.
4. Use one of the soluble phosphates.

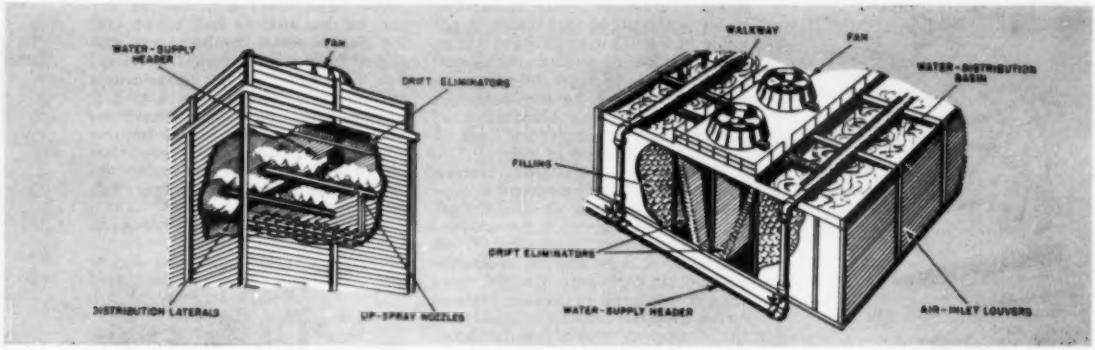


Fig. 7. Induced-draft tower of combination spray-filled and wood-filled design
In wood-filled part of tower, pieces of lumber laid horizontally on centers as close as desired without introducing too much air flow resistance. Water from spray heads distributed over top layer drops from filler to filler piece and air moves up or across wood filling, which presents large wetted surface, repeatedly breaks up falling drops, giving integrated drop surface area several times that of wood fill area

Fig. 8. Double-flow (or cross-flow) induced draft tower, designed for compactness, better construction, lower cost, larger capacity, improved performance
Employs horizontal air flow, fans centered along top. Each fan draws air through 2 cells paired to a center suction chamber partitioned midway beneath fan, with drift eliminators to turn air up toward fan outlet. Pumping head from 12 to 30 ft. Water loading usually about 6 gpm per sq ft maximum, because of blanketing effect of spray; but loadings up to 10 gpm possible for steam condenser service. Low draft loss, longer air travel, open water-distribution basin at top accessible for cleaning during operation; diffusion deck for uniform distribution to filling. Occupies less than 1/20 area of equivalent spray pond to produce a given water-cooling effect

5. Convert the carbonates to sulphates by adding sulphuric acid.
6. Use chromates.
7. Regardless of the water-treatment method used, a systematic program of blow-down should be established to control the dissolved solids in the circulating water.

Algae. Algae formations may plug nozzles and prevent proper distribution of the water over the tower filling. This growth may also collect on the equipment served by the cooling tower and thereby decrease the heat transfer rate. In addition to algae, a microscopic examination of slime, which may accumulate on the water side of various heat transfer surfaces, shows inorganic matter bound by filamentous forms of bacterial growth. Destruction of this slime by chemical treatment of the water eliminates the binder for this inorganic matter and thus precludes the possible future growth of algae.

Chlorine is a chemical frequently used as algaecide; it is an effective and inexpensive means of controlling this troublesome growth. Regardless of the algaecide used, the growth, in time, may become immune to that chemical and the treatment must be changed. This new treatment is continued until the old treatment again becomes effective. Other chemicals that can be used effectively to control algae are: copper sulphate, liquid bromine, potassium permanganate, chlorinated lime, and various blends of chlorophenates.

It would be expedient to begin the use of an algaecide before too much algae has begun to grow, otherwise too much of the growth would be killed at one time, and the dead algae would tend to clog the system

The Language of Cooling Towers

COOLING TOWER DEFINITIONS

A WATER-COOLING TOWER is an enclosed device for evaporatively cooling water by contact with air. In atmospheric water-cooling equipment the heat transfer is accomplished partially by a transfer of sensible heat (about 25 per cent) which raises the wet-bulb temperature of the air; but most of the cooling is due to an exchange of latent heat (about 75 per cent) resulting from the evaporation of a small part of the circulating water.

A NATURAL-DRAFT TOWER is one in which the air movement through the tower is dependent only upon atmospheric conditions.

A SPRAY-FILLED TOWER (natural draft or mechanical) is one which is dependent solely on spray nozzles for water break-up.

A DECK-FILLED TOWER is one which contains baffling to increase the water break-up of the distributing system and to provide additional wetted surface.

A MECHANICAL-DRAFT TOWER is one utilizing one or more fans to move air through the tower, the fans being an integral part of the tower.

A FORCED-DRAFT TOWER is a mechanical-draft tower having one or more fans located in the air intake to the tower.

AN INDUCED-DRAFT TOWER is a mechanical draft tower having one or more fans located in the air outlet from the tower.

OPERATING TERMS

Those who operate or manufacture distinctive major mechanical equipment or apparatus gradually develop a somewhat specialized "glossary" of words and phrases that describe particular related functions, parts, or characteristics of such equipment. The most common of such terms as applied to atmospheric water-cooling equipment are the following:

COOLING RANGE is the number of degrees F that the water is cooled with the water-cooling equipment. It is the difference in temperature between the hot water coming to the cooling tower and the temperature of the cold water leaving the tower.

APPROACH is the difference in degrees F between the temperature of the cold water leaving the cooling tower and the wet-bulb temperature of the surrounding air.

HEAT LOAD is the amount of heat dissipated by the water-cooling tower in Btu per hour (or per minute). It is equal to the pounds of water circulated times the cooling range.

PUMPING HEAD is the pressure required to lift the water from the top of the water in the basin to the top of the tower and force it through the water distribution system. It is equal to the static head plus the velocity head and friction loss in the water system.

DRIFT is the small amount of water that escapes from atmospheric water-cooling equipment in the form of fine droplets and is that water which is entrained by the circulating air. Drift is a water loss independent from that water lost by evaporation; it can be reduced by good design.

BLOW-DOWN (bleeder by-pass or waste) is the continuous or intermittent wasting of a small part of the circulating water in order to minimize harmful concentrations of chemicals in the water. In most localities the water used in a cooling tower contains dissolved solids. The water that is evaporated in the tower does not carry away its solids and as a result the solids concentration is built up unless some of the concentrated water is drained off and replaced with make-up water. These solids decrease the evaporative properties of the circulating water, and they may cause sludge deposits in the system or corrosion of metals.

MAKE-UP water is that required to replace the water lost by evaporation and drift and blow-down.

These definitions, in general, conform with the ACRMA Proposed Standard on "Cooling Towers for Use with Refrigerating Equipment;" Air Conditioning and Refrigerating Machinery Association, Southern Building, Washington, D. C.

Fig. 9. On cross-flow tower with open water distribution basin at top, workman cleans and maintains without shutting tower down

as it is carried off by the circulating water.

Delignification. Delignification is defined as the decomposition of lumber wherein the lignins of the wood are dissolved by the chemicals of some cooling waters. It is generally caused by the combining of sodium carbonate, held in the cooling water, with the lignins and part of the cellulose products of the wood. Delignification leaves the wood in long, stringy fibers. Prolonged exposure reduces the structural strength of the wood. The critical points in the tower, with respect to delignification, are the parts that are alternately wet and dry. Here, evaporation greatly increases the concentration of the sodium carbonate.

An indication of the extent of sodium carbonate in the circulating water is the pH of that water. A pH value of 9 to 11 may indicate a high concentration of sodium carbonate; it is desirable to keep the pH value between 7 and 8. In any case, the primary problem is elimination of the sodium carbonate and not of necessity a question of pH.

The water treatments recommended in the scale prevention section above are set up to keep the pH value and the tendency toward delignification at a minimum. When sulphuric acid is used to neutralize the sodium carbonate, the pH value should be kept at about 7.5 and never dropped below 7.0 because of the danger of corroding the heat-exchanger equipment, unless inhibitors have been added.

Two-Speed Motors

For readily adapting tower performance to temporary or seasonal decreases in heat load, and especially for winter operation, use of two-speed motors for fan drives is recommended. The chief advantage is that when operated at half-speed, fans require only about 15 per cent of the power used at full speed. Particularly in multi-fan towers, the ready flexibility provided by two-speed motors results in considerable savings, even though load reductions may sometimes call for only one or a few fans to be operated at half speed.

When fan-speed is reduced to half, the hot and cold water temperatures of a cooling tower will increase 6 to 8 F for a given wet-bulb temperature and heat load. When the wet-bulb temperature is 10 F below design temperature the fan can be operated at half speed and the design water temperatures obtained for a given amount of water. For the same wet-bulb temperature and the same range (but 6 to 8 F higher hot- and cold-water temperatures) a tower would require approximately 60 per cent more effective cooling area at half fan-speed than at full-speed operation for a desired heat load.

Another speed consideration is

Fig. 10. On double-flow tower, walkways along distribution basin facilitate inspection and safe operation

that, during the winter months when it is not cold enough to shut down the fans completely, yet cold enough so that ice tends to form at full fan speed, the condition may be met readily by operating some or all of the fans at half speed.

Starting Up

Before a water-cooling tower is started up for the first time, or after a long shut-down, it should be thoroughly cleaned and inspected. Remove all dirt and trash that has blown, or otherwise collected, in the

TABLE 1—MAINTENANCE CHECK CHART

Part to Be Serviced	Distribution System				Gear Box				Drive Shaft				Motor				Filling				Cold Water Basin				Structural Members			
Frequency	W	S	Y	R	W	S	Y	R	W	S	Y	R	W	S	Y	R	W	S	Y	R	W	S	Y	R	W	S	Y	R
Inspect for clogging	X																	X			X							
Check for unusual noise or vibration					X				X				X													X		
Feel for overheating													X															
Check shafts for lateral movement					X								X															
Inspect keys and keyway					X								X															
Check oil level and oil for water and dirt					X								X															
Make certain vents are open					X								X															
Inspect for deterioration																		X				X				X		
Lubricate				X		X			X							X												
Tighten loose bolts				X		X			X																			
Repaint								X				X				X								X				X
Dry out															X													
Clean				X																X				X				
Renail (if necessary)																		X										

W—Weekly; S—Semi-Yearly; Y—Yearly; R—As required.

catch basin beneath the tower. Clean suction screens as well as nozzles and other parts of the water distribution system located near the top of the tower.

Inspect fans (if used) and make sure that all bolts are tight, that fans rotate freely, and that ample clearance exists between blade tips and fan cylinder. Check the fan driveshaft and see that all bolts are in place, that flexible couplings or universal joints are in good condition, and that the shaft guards are in position and properly secured. Motor, drive-shaft, and speed reducer should be aligned.

Make sure that speed reducers are filled with the proper grade and quantity of clean oil. Also see that the vent connection on top of the speed reducer is open. Inspect motors and make sure that they are properly lubricated. Tighten all motor frame and anchor bolts. Inspect nozzles, piping, and flumes of the water distribution system. Look over the framework of the tower and tighten all loose bolts. On wooden towers, do not tighten bolts too much or the swelling of the wood may break them.

See that the catch basin is free of leaks. Small leaks in wood basins

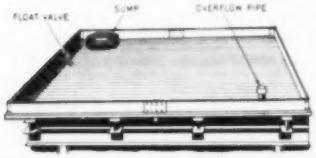


Fig. 11. Typical cooling-tower basin, of redwood or steel, through bolted to foundation, equipped with umbrella-covered overflow pipe, float valve for make-up, and sump

will stop when the wood becomes soaked. In concrete basins pay particular attention to expansion joints in the walls and floor. If a float valve is used for make-up, be certain that it works freely and does not leak when closed. Inspect the overflow to make sure it is open. Check the sump assembly to see that the screen and cover (or suction screens in the case of concrete basins) are properly installed.

Fans

Start the fans and inspect them immediately to make sure that they are running freely. It is very important that fans should rotate in the direction specified by the tower manufacturer. Check the power input to the fan motor. If these motors are not loaded in accordance with the specified horsepower, contact the manufacturer to obtain instructions for setting the fan-blade pitch.

Speed reducers are sometimes noisy when started for the first time, but will generally quiet down when properly broken in. Excessive noise developing in speed reducers after they have been in operation for some time indicates considerable wear and probably need for repair.

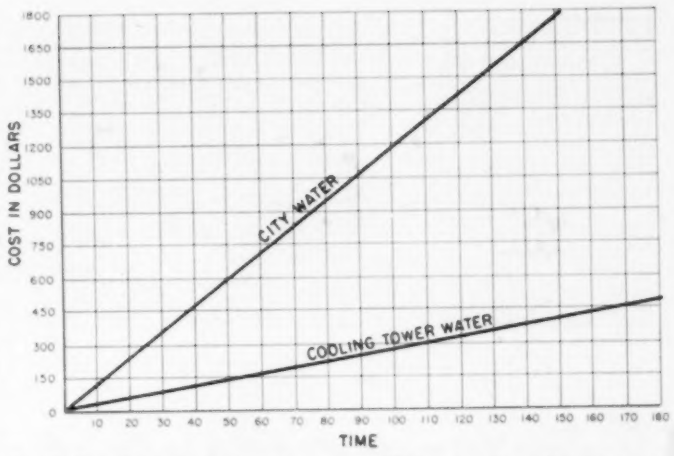


Fig. 12. Operating costs of water and power per 1000 hr, for cooling refrigerants, based on 78 F wet bulb
City water—Circulating 1½ gpm per ton of refrigeration—cost* $1 per 1000 cu ft
Cooling Tower Water—Circulating 3 gpm per ton of refrigeration plus power costs for fan and pump

Circulating Water System

The float valve should be adjusted to maintain a water level in the catch basin of 5 to 6 in. below the wood filling. Maintain at least 6 in. of water in redwood or steel basins. Place all valves in open or closed position as required, and prime and start the circulating water pumps. Check the amount of water being circulated and adjust to approximately the quantity for which the tower was designed. Water flow can be checked by means of an orifice meter, weir, pitot tube, or pump performance curves. Equalize water distribution so that all parts of the tower are receiving like amounts of water.

Operation

To obtain the best operating results, the distribution system and the catch basin under the tower must be kept free of dirt, algae, and scale. Fans driven by variable speed devices must not be operated above the speed for which they were designed. Concrete basins should be provided with doubt suction screens; that is, one set of screens placed in front of another and so positioned that all of the water goes through both. When cleaning screens, remove, clean and replace the screen through which the water first passes before removing the second screen for cleaning.

Inspect oil in speed reducer weekly and add oil when necessary to maintain proper level. Drive shafts equipped with splines, gears, or universal joints should be greased weekly. Drive-shafts equipped with couplings using rubber-bending members do not require lubrication.

A regular daily inspection schedule is recommended to determine whether the cooling tower is operating properly. The cooling tower in operation becomes but part of a system made up of several other auxiliaries. Therefore it may be blamed for unsatisfactory performance which is only a symptom of failure in another part of the system.

Reduced cooling range indicates a light heat load or excess water quantity. Increased cooling range indicates heavy heat load or insufficient water quantity. When a condenser becomes badly scaled, water quantity circulated is frequently retarded and pumping head increased. Higher cooling water temperatures usually indicate this condition. Thus, if water quantity is incorrect, (1) check pump for speed, pressure, and freedom from air, (2) check condenser for scale, air, or restrictions, and (3) check pipe lines for air, partially closed valves, dirt, or restrictions.

Cold-Weather Operation

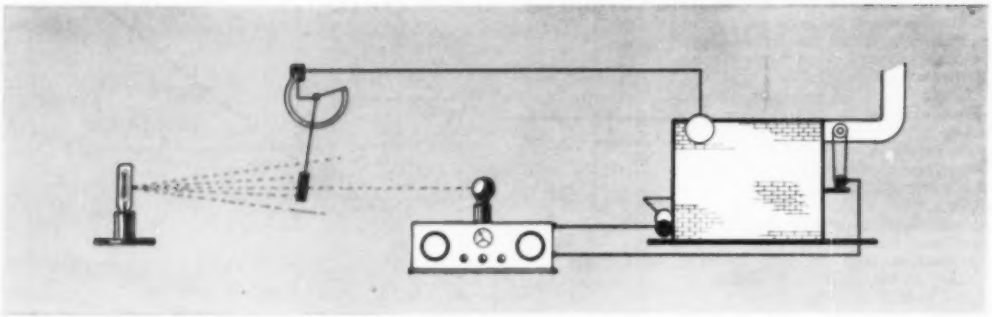
Extremely cold water normally does not increase performance to any great extent, but operating

(Continued on page 120)

Table II—Total heat content of air at various wet bulb temperatures

TOTAL HEAT CONTENT OF AIR AT VARIOUS WET BULB TEMPERATURES
at Standard Barometric Pressure

W.B. Temp. °F	BTU per Pound	W.B. Temp. °F	BTU per Pound	W.B. Temp. °F	BTU per Pound
30	10.89	54	22.55	78	41.42
32	11.73	56	23.77	80	43.51
34	12.56	58	25.05	82	45.72
36	13.41	60	26.37	84	48.05
38	14.28	62	27.76	86	50.47
40	15.19	64	29.21	88	53.02
42	16.13	66	30.73	90	55.70
44	17.11	68	32.31	92	58.52
46	18.12	70	33.96	94	61.50
48	19.16	72	35.70	96	64.62
50	20.15	74	37.51	98	67.92
52	21.38	76	39.42	100	71.40



Electronic Control for Small Boilers

The Hodgkinson Electronic Combustion Control System developed in England was designed for application on small boilers where the expense of a more elaborate system cannot be justified. In this system the actuating impulse is derived from a Bourdon tube arranged to control a photoelectric cell. The amplified impulses of this cell actuate both the damper and the stoker drive. A full description of this system appeared in the February issue of the Engineering and the Boiler House Review published in England and a description of the first installation of this system in the plant of the Royal Manchester Children's Hospital was presented in the February issue of The Steam Engineer also published in England. The detailed account of this system of combustion control given here is based upon the data given in both of these articles

THE AUTOMATIC combustion control system described in this article was developed in Great Britain by Messrs James Hodgkinson Ltd and is intended for application on small boilers where the complexity and expense of a more elaborate control system would not be justified. It is the culmination of some two years of research and experiment, the aim from the early stages being to produce a reliable mechanism which, although marketable at a reasonable price, would still offer the advantages of a sensitive fully floating modulating control.

In order to simplify manufacture and installation, it was decided to concentrate on a unit system of construction and to carefully avoid, as far as possible, any mechanism which required an undue amount of precision in its manufacture. In the initial stages of the design, therefore, resort was made to the simple Bourdon tube instead of diaphragms to provide the actuating impulse for the control system. It was realized however, that the Bourdon tube could furnish very little power so that any ordinary type of piston valve or even electrical contact would be out of the question.

Bourdon Tube is Basic Element

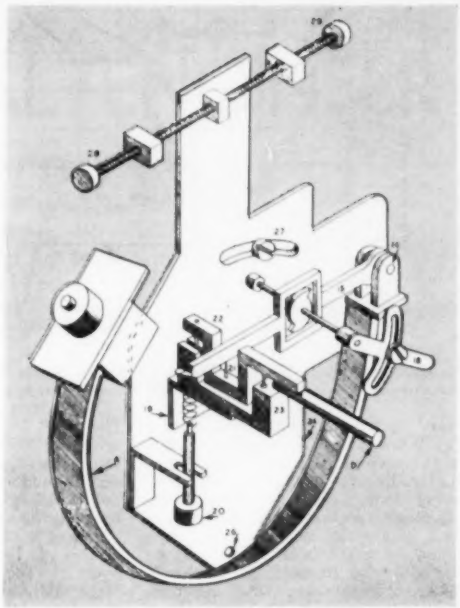
Preliminary experiments were conducted with a standard pressure gage assembly, the magnification of the tube deflection being effected by means of the usual quadrant and pinion with a phosphor bronze hairspring to eliminate backlash. Two special stop-pins were fitted, the first pin forcibly deflected the tube by an amount corresponding to an internal pressure of 100 psi, while the second limited the movement of the tube after the internal pressure had reached 105 psi. Thus the gage needle remained at rest until 100 psi had been reached, floated freely through a 5-lb range, and then remained locked irrespective of how much the pressure was increased. It was soon found, however, that although the quadrant and pinion method of amplifying the movement of the Bourdon tube was economical in that it was a standard fitment of most pressure gages, it was far from being frictionless in operation. In fact, one only had to tap the assembly lightly to cause the needle to "jump" a distance corresponding to fully ½ psi. Since it was intended to construct an instrument which would be sensitive to pressure changes of approximately one-eighth of this figure clearly the development of some other magnification system was essential. The outcome of a series of subsequent experiments resulted in the design illustrated diagrammatically in Figs. 1 and 2.

In view of the very small amount of power available from the Bourdon tube, the method adopted for "transmitting the message" from the Bourdon tube to the stoker speed control and damper mechanisms, was to fix a vane or mask to the end of the gage needle and cause this to interrupt two beams of light.

This arrangement for interpreting the messages initiated by the Bourdon tube proved to be ideal as apart from being entirely frictionless it interfered in no way with the freedom of movement of the gage needle. Accordingly, the thin metal vane used was about 1½ in. square and attached to the pointer which was extended so that the extremity of the vane lay 10 in. from the ful-

crum. It was then found that with the new magnification linkage that a change of pressure amounting to no more than 1 in. to 2 in. w.g. was sufficient to procure a measureable defection of the vane. A screen having two slits was arranged close to the vane, and in front of each slit was positioned a small electric light bulb. On the opposite side of the vane there were two photo-electric cells of the Barrier Layer type. When the vane was in the central position, the two beams of light from the slits were just interrupted by the edges of the vane so that both cells were in darkness. A slight movement either way, however, caused the mask to expose one of the slits and a narrow beam of light to strike one of the cells. Thus, if the left-hand cell (henceforth known as cell X) receives light, the indication is that a fall in pressure is occurring and if the right-hand cell Y is illuminated, the pressure is increasing. The current generated by the cell has to be amplified before it can be used to operate a relay and a magnetic type of amplifier was tried with very good results. The direction of rotation of the operating motor was determined by two sub-relays each provided with four contacts:—three being to make the necessary motor connections, and a fourth to hold the relay in the closed position after momentary excitation.

Fig. 2. Diagram of the Bourdon tube type of pressure sensitive element



First Control Installed in Hospital Plant

The prototype control was assembled and put into operation on a boiler at the Royal Manchester Children's Hospital where it has produced some most encouraging results. Moreover, this plant proved to be a useful installation for test purposes because not only was the load subject to very wide fluctuations, but the boilers and automatic stokers were in excellent condition, and the resident engineer cooperated whole-heartedly in the application of the prototype control equipment.

In the meantime, tests have continued, using an alternative photo-electric system. Instead of the Barrier Layer cell and magnetic amplifier combination, a BTH photo-relay with a Mazda cell was tried. This is supplied complete as a single unit in a die-cast casing and has proved a good deal more sensitive than the first arrangement. This greater sensitivity made it possible for the light sources to be reduced in intensity by under-running the bulbs with the intention of prolonging their life. At the same time the cell was moved much farther away from the lights and the two beams could now be made to converge on the single photo-cell which, since it was mounted on the chassis of the amplifier, remained permanently connected to it. The amplifier is of the thermionic type with a single-stage through a standard four-pin radio tube which is easy to replace. It was now, of course, no longer possible to detect which slit was being uncovered from the response of the cell, as this would be the same no matter which way the vane was deflected. Accordingly, the wiring through the process timer was revised so that instead of passing the current from two cells and two relays, it now handled that for the two lamps and the two relays. This alternative proved to be a great improvement as the problem of handling microamps through lightly tensioned silver contacts was at once eliminated. The switching now followed a different sequence and for an interval of three seconds the X lamp was illuminated while the X relay was in circuit with the master

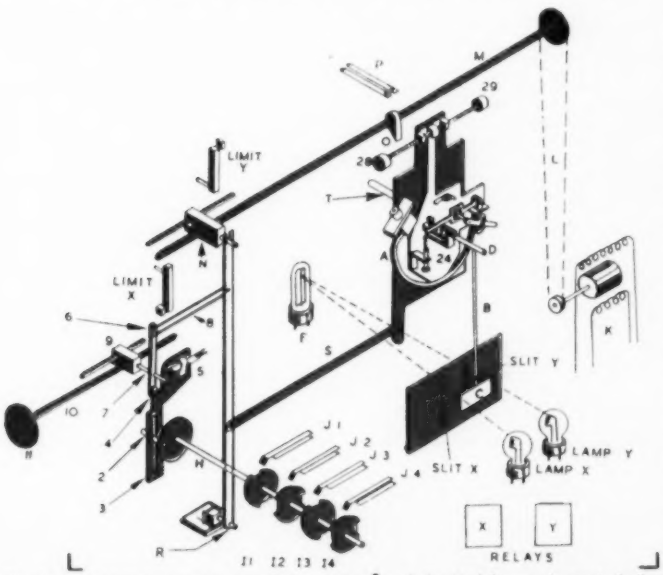


Fig. 1. Diagrammatic arrangement of the mechanism of the Hodgkinson electronic boiler control instrument

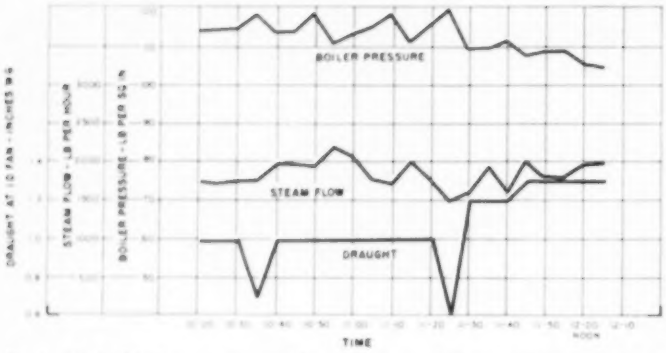


Fig. 3. Graph of boiler pressure, steam flow and draft at the Royal Manchester Children's Hospital compiled from readings taken when the boiler was operating under manual control

relay in the amplifier; 15 sec later the Y lamp was illuminated and the Y relay connected to the amplifier. As before, the cycle was repeated every half minute, so that if the photocell receives light during the first half-cycle, this can only have come from the X slit and current can only be transmitted to the X relay, with the result that the pulling motor can only run in the direction dictated by that relay. Reference to the illustration will assist in following the working principles of the mechanism.

Details of Operation

The steam pressure from the boiler is transmitted to the Bourdon tube A through a flexible coiled copper pipe, the expansion or contraction of A being transmitted to the arm B which carries at its end the vane or mask C, this vane is free to swing to the left or to the right since it is pivoted on the shaft D; the enlarged diagram shows the magnification mechanism in detail. The Bourdon tube terminates in bracket 14, in which is fitted a pin which also passes through bar 15, this bar being provided at its centre with a square aperture. Inside the square is fitted a cam mounted on a shaft, and by rotating lever 18, the extent of the movement of bar 15 in a horizontal plane can be increased or limited. By this means it is possible to determine the range throughout which the vane C will be free and its movement so influenced only by the Bourdon tube. Usually this range is of the order of 5 psi. The left-hand end of 15 has a vee-notch in the upper surface in which lies the loop of a spiral tension spring, 19, adjusted by screw 20. The spring holds bar 15 down on the needle point 21 located in a recess in the underside of the bar; needle 21 is fixed in yoke 22 in which are fitted two similar needles, while the yoke carries shaft D. The tip of the outer needle rests in a recess in block 23 and that of the inner, in a vee-notch cut in the same block. The shaft 17, the block 23 and the screw 20 are all mounted on plate 24, which is carried on baseplate 25 and pivoted at 26; the Bourdon tube, being rigidly mounted on 25. Thus, by pivoting 24 about centre 26 the whole of the assembly can be shifted to the left or to the right with respect to the tube, and an initial force imposed on the tube corresponding to the pressure at which the mechanism is to operate. This movement is controlled by the two screws 28 and 29, and to set the mechanism for a higher pressure range, 27 is slackened and 28 is turned in a clockwise direction while 29 is being slackened; 27 is then retightened to lock the plate 24 in position.

When the vane C is in the central position it just obscures slits X and Y and so prevents light reaching the cell F from the two bulbs X and Y. The shaft H is being continually rotated by a synchronous clock motor at 1 rpm and on this shaft are mounted four cams I_1, I_2, I_3 and I_4 forming the process timer. Each cam has two notches on its profile and displaced at 180 deg. Cams I_1 and I_3 are in phase as are cams I_2 and I_4 the first two being set at 90 deg to the others. Contacts $_1$, $_2$, $_3$ and $_4$ are arranged to "make" when their respective riders, J_1 to J_4, coincide with the notches on the cam profile.

Assume that there is a drop in steam pressure so that the vane C swings slightly to the right and exposes slit X then within 30 sec the cam I_1 will cause lamp X to be illuminated for a period of 3 sec and at the same instant the cam I_3 will connect the master relay in the amplifier to relay X. The photo-cell having received the light signal, closes the master relay, which in turn supplies power to relay X, causing the latter to close. When relay X closes, the pulling motor K commences to run in a clockwise direction, this motor being used to drive shaft M, the left-hand end of which is screwed and carries nut N. During one revolution of shaft M, trip O breaks its holding circuit by opening switch P and the motor K is then stopped. In the meantime, since M has made one turn, the nut N has travelled one thread to the left. This motion is transmitted to bar Q which is pivoted at R, the movement to the left being imparted through link S, to the plate 25 which can turn on shaft T. The centre lines of T and D approximately coincide, and then the Bourdon tube assembly is slightly tilted by the travel of nut N to the left, tending to cause vane C to obscure slit X again. This follow-up linkage is intended to avoid undesirable "hunting."

From bar Q or from shaft M control of the boiler dampers or fan speed can be effected, and the same source of power might also be employed to govern the speed of the mechanical stokers. The actual stokers at the Royal Manchester Children's Hospital, however, are adjusted in an altogether different manner which obviates the necessity of providing variable speed motors. On the camshaft H of the process timer is the disc 1 on which is fixed a crankpin 2. The rotation of this disc oscillates slotted arm 3 about pivot 4. Rigidly mounted on 3 is mercury switch 5 which makes and breaks a circuit on a 1 min frequency cycle by virtue of the con-

(Continued on page 132)

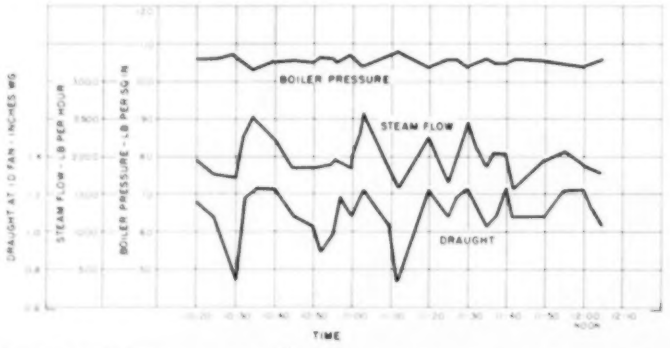


Fig. 4. A graph similar to the one in Fig. 3 but taken over the same period when operating with the automatic boiler control

The PRACTICAL ENGINEER *and* ELECTRICIAN

ANDREW W. KRAMER, EDITOR

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WARNING! DON'T SLEEP ON 1200 PSI STEAM LINES

Rochester, N. Y. has an extensive central heating system supplying low pressure steam to a large proportion of the residences in the city as well as to commercial establishments. This steam is supplied from the steam-electric generating stations within the city. Part of the system involves a 1200 psi steam line something over a mile long installed between two of the generating stations. Naturally, the design and construction of such a long, high pressure, high temperature steam line required very careful consideration of the expansion to which it is subjected. One of the difficulties which the operators of this line have had arise not from technical considerations but from the habits of hobos. These hobos, it seems, discovered several places where the line is easily accessible and in cold weather found it convenient to warm themselves on it. Although the line was protected by an aluminum covering over the insulation, the resourceful hobos managed to tear off the metal covering at certain strategic points and sleep between the line and the concrete duct through which it runs. Unfortunately, one of these hobos had not studied the practical effects of expansion and this proved disasterous. Not long ago, a bad odor prevailed close to the center of town. Investigation showed that the odor came from the duct carrying the pipe line and further search disclosed the decayed body of a hobo crushed between the pipe line and the concrete duct. It was a bad job getting him out.

A Section of Power Engineering Devoted to
PLANT OPERATION AND MAINTENANCE
Technical Publishing Company
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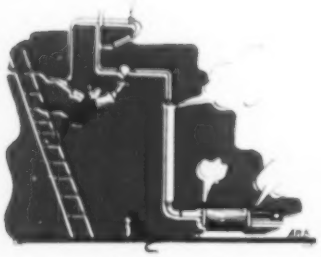
The Practical Engineer -- WHO IS HE?

The Practical Engineer belongs to no particular class or rank. He may be the superintendent of a billion dollar utility system or a fireman in a small boiler plant; it is their thinking and background of experience that make them brothers under their respective stations in the important field of power engineering

By ANDREW W. KRAMER

ALMOST ELEVEN YEARS AGO, in July 1939 we started a new section in *Power Plant Engineering* which we called the Practical Engineer. As we pointed out in that first issue, in this section we expected to deal largely with facts—facts that had been tried and proved by practical men in the field; a section where practical engineers could give and receive help in the practical operation and maintenance of equipment for *both the generation and utilization* of power.

From the beginning, this Practical Engineer Section was very popular, not only with the so-called practical type of operator but with many men higher up, technically trained engineers, specialists of various kinds, superintendents and chief engineers. This wide range of interest in this section did not surprise us, indeed we anticipated it because our many years of close contact and association with power engineers in all kinds of plants indicated a distinct need for the type of information we put in the Practical Engineer Section. We had experience of our own to guide us. As young squirts we had worked in power plants ourselves and had learned in the hard school of experience what engineering should not be. In the first World War we had engaged in the fanciful task of saving the world for democracy and as embryo naval officers had worked as members of the black gang in the engine rooms of our so-called 90-day ships. Many of the shipboard plants we toiled in, it was obvious, had been built by any but practical engineers. No man who ever had to manipulate a valve could possibly have installed valves in the incredible locations and positions we actually found them; indeed, often we never found them—there were no valves where valves ought to have been.



The incredible positions of the valves

To a draftsman, working in the comfortable seclusion of the drafting room, a valve no doubt meant merely a symbol somewhere on an expanse of white paper, but to us in the engine room it meant something that could be reached without having to crawl down into the bilge or having to become a contortionist at the top of a ladder.

Our difficulties with the outlandish geography of the mechanical equipment in some of these plants served indelibly to impress on our minds the difference between "practical" and impractical engineering. The designers of these plants may have understood the theoretical elements of steam engineering but it was overwhelmingly obvious that they had no knowledge of the practical side of engineering. Only an operator who has repeatedly cursed the stupidity of some designer in placing a valve in a location where only a gymnast could reach it, really knows how and where a valve should be placed.

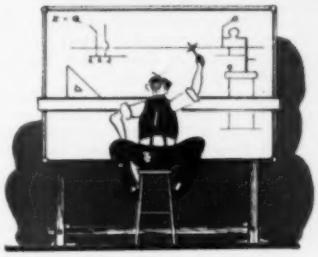
The point of all this is that the practical engineer's knowledge is born of practical experience in the field he serves. The practical engineer belongs to no particular class or rank; he may be the superintendent of a billion dollar utility system or he may be the fireman in a small heating plant—their realms of action may be at opposite poles, but the nature of their thinking and knowledge rests on the same foundation—experience, and that in a sense makes them brothers. What they know, they know because they have *done it*, not because they have read it or because somebody told them. One can read about such a simple thing as cutting and fitting a gasket until he feels that there is nothing more to be known about it, but until one has actually cut and put a gasket in place, he has much to learn about the operation. The intangibles are never put in the book.

This does not mean that the practical engineer is not susceptible to the ideas of others or that he cannot learn by reading, for if that were the case we might as well stop right here. The practical engineer assimilates knowledge as readily as anybody else but before he can accept a new idea he must project it against the background of his own experience in order to evaluate its usefulness. He does this unconsciously, of course, but he does it nevertheless, and that is why his apparently *snap judgment* often is more correct than the so-called reasoning of theorists. It was a theorist who proved by involved, supposedly-scientific calculation early in the 19th century that a steamship could never cross the Atlantic because it could never carry sufficient fuel for the voyage. It was a practical man, however, who brought the first steamship across the ocean almost before the theorist's prophecy appeared in print.

It was because we realized the importance of these practical aspects of engineering that the Practical Engineer Section was inaugurated. It appeared in every issue for a period of ten years—until May 1949—and then it was discontinued. In publishing practice the trial and error method is one method of determining what readers like and what they don't like, and in this case the Practical Engineer Section was removed to see how readers would react to the change. We continued to present the same type of practical material but it was no longer concentrated in a special section.

A year's experience with the Practical Engineer Section removed convinces us that it should be put back and so with this issue we are resuming its publication. As before, we will again make every effort to make this section of maximum interest to practical engineers regardless of the positions they may hold. As much as possible we will endeavor to make the Section a forum where men with practical ideas can present them for the benefit of others. In addition to practical articles of special interest, there will be a good Hints and Kinks department and the Questions and Answers department will be maintained at a high level of interest and helpfulness.

If you have any ideas which you have put into practice and found useful, send them in; they may help some other fellow and his methods in turn may be of value and assistance to you.



To a draftsman a valve is merely a symbol

Why The Turbine Would Not Take Full Load

This shows that it is not wise for a maintenance man to jump at conclusions no matter how smart he may be. In this case, the operator with less knowledge but with more patience found the solution to a baffling problem by investigating details of a mechanism that the expert had overlooked

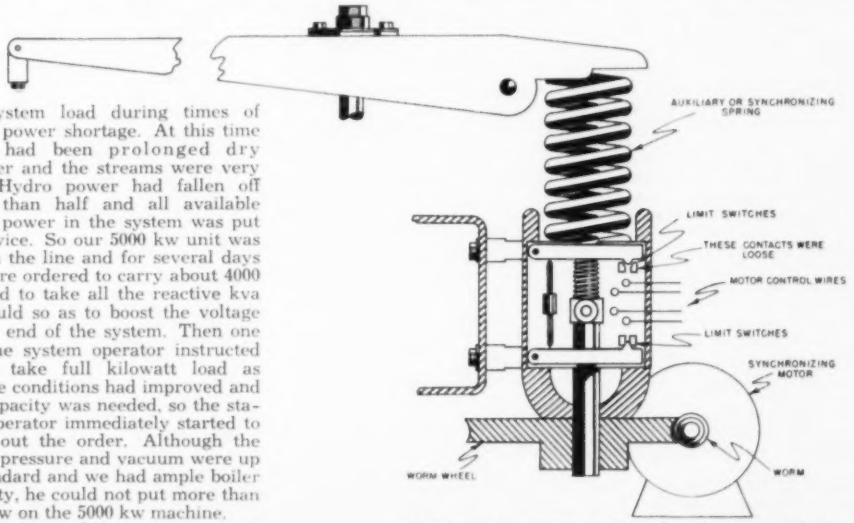
By ALBERT H. MOULTON

SEVERAL YEARS ago in a small electric utility there was a 5000 kw turbo-generator set that had been shut down for several years, except for an occasional run to help out system load during times of hydro power shortage. At this time there had been prolonged dry weather and the streams were very low. Hydro power had fallen off more than half and all available steam power in the system was put in service. So our 5000 kw unit was put on the line and for several days we were ordered to carry about 4000 kw and to take all the reactive kva we could so as to boost the voltage at our end of the system. Then one day the system operator instructed us to take full kilowatt load as voltage conditions had improved and full capacity was needed, so the station operator immediately started to carry out the order. Although the steam pressure and vacuum were up to standard and we had ample boiler capacity, he could not put more than 4300 kw on the 5000 kw machine.

Now this turbine governor as is usual, had an auxiliary spring controlled by a tension screw worm geared to a synchronizing motor which could be operated either by hand or by remote control from the switchboard, and served to regulate load when machine was on line.

To safeguard the control mechanism from damage due to overrunning the limits of the adjusting screw, limit switches were put in motor circuits to open them and stop the motor as screw neared end of its travel.

When the operator tried to take full load the motor would apparently run up to its full limit and throw the limit switch for that position before all turbine valves were opened. Working the screw by hand, all steam valves could be opened, but this was a slow process as it took several hundred turns of the hand wheel to do what the motor could do in a few seconds. The chief was away at the time so the operator sent for the head electrical maintenance man, who came and looked it over and while he and the operator watched, the assistant operator ran the motor back and forth enough to throw the limit switch in and out



Sketch showing relative positions of synchronizing mechanism

from the switchboard. Always the limit switch would fly out at this same point just before the two last steam valves opened.

This maintenance man, who was a well experienced all-around electrical "trouble shooter," decided that there was nothing wrong with the control motor, and that the opening of the limit switch was a safeguard and perfectly normal. When the operator asked him why it was that the motor control, which used to run the governor up so as to open all valves, would not do so now, he replied that it must be something in the hydraulic gear. This, he said, was out of his line and so he dropped the matter back into the operator's lap and went about his own business.

After he left, the operator, who was not what would be called an electrician, but who had had considerable experience in electrical work and turbine operation and was a licensed engineer, went back and took another look at the limit switch contacts and noticed one of the switch blades and contact jaw were a little worn, and as there must be some reason why it would not work, perhaps this was it. The switch was designed to give quick break by coming up against spring tension, when sufficient tension was reached it would snap out (as shown in sketch). With this in mind the operator waited until load conditions would permit lowering the limit switch blade back into contact which, of course, necessitated changing the governor auxiliary spring tension and dropping some load. When this was done and the blade was back in its contact, it was readily seen that it was a little too loose and so would allow the blade to snap out too soon. This was remedied by one little squeeze on the switch jaw with a pair of pliers. At the first try after this slight adjustment the adjusting screw could be run up to its proper height and the limit switch snapped out and all turbine valves were opened. Thus, we could take full load again in the usual way. All of which goes to show how a "crack-a-jack" electrical man who had solved many knotty electrical operations, was thrown by this little "gimick" because it was too simple.

How to Maintain Gearmotors

CONSIDERABLE TIME frequently elapses from the time the gearmotor is shipped from the manufacturer until it is placed in operation by the customer. So it is important that the crating of a gearmotor be examined as soon as it is received for evidence of damage due to rough handling.

The gearmotor is shipped bolted to skids that form the bottom section of the shipping crate. When the top and sides of the crate are removed, leave the gearmotor bolted to the skids for ease of moving until it is to be mounted on its foundation. When removed from the skids or lifted to its place on a foundation, the gearmotor should be lifted by a sling.

Unit should not be lifted by the eyebolt in the motor frame. This eyebolt has been designed to support only the weight of the motor and the adapter plate and is furnished to simplify the job of removing the motor from the gear portion of the unit.

When the unit must be stored for any length of time before installation, the storage location should be dry and clean, and the temperature as constant as possible. The gearmotor must be filled with oil and manually rotated at least once a week to distribute a film of oil over the internal parts and prevent corrosion.

These points were reviewed in a recent issue of Westinghouse *Maintenance News* by C. W. Miller, Chief Inspector, Gearing Div., Westinghouse Electric Corp. He then gave the following instructions as a basic plan for this equipment.

Foundation

A foundation or mounting which provides rigidity and prevents "weaving" or "flexing," with resultant misalignment of the shafts, is essential to the successful operation of a gear drive. Use a concrete foundation whenever possible.

Gearmotors are designed with a tolerance of + 0 and — 1/32 in on the dimension between shaft center and base, therefore shimming may be required. Shims of various thicknesses, slotted to slide around the foundation bolts, should be used. After alignment has been secured through shimming, the gearmotor can be bolted down and grouted in. (See B, accompanying sketch.)

When the unit must be installed on structural foundations, a supporting base plate of steel, with a thickness not less than the diameter of the holding-down bolts, should be provided to obtain proper rigidity. (See A, accompanying sketch.)

Securing Alignment

If the gearmotor is connected to driven equipment by a coupling, correct alignment cannot be overemphasized. Alignment becomes of greater importance as speeds are increased or the drive is subjected to variations in load conditions. Misalignment, either parallel or angular, is one of the most frequent causes of bearing or shaft failures. The resultant extra load causes noisy operation or excessive operating temperatures.

Misalignment not exceeding 0.002 in. will not affect operation of the gearmotor. Check alignment by the well-known methods employing straight edges and feeler gages or dual indicators.

Gearmotors are intended, unless otherwise specified, to be mounted

Operation maintenance check chart for gearmotors

TROUBLE	PROBABLE CAUSE	CORRECTION
Noisy operation of unit	1. Misalignment	1. Check alignment of unit with driven member. Check condition of couplings, if used.
	2. Faulty lubrication	2. Check oil level. Determine if lubricant is of grade recommended.
	3. Excesive tension, if power take off is by belt or chain drive.	3. Check tension and alignment of drive auxiliaries; relieve if necessary. (See that driving pulley or sprocket is mounted as close to the unit as possible.)
	4. Worn parts caused by normal length of service, or possibly a result of (1), (2) or (3) above 5. Overloading	4. Adjust or replace worn parts as per procedure outlined under Replacement of Parts.
Excessive operating temperature	1. Incorrect lubricant	1. Check oil against specification instructions.
	2. Incorrect amount of lubricant	2. If check shows low oil level, fill to level indicated by nameplate. Drain a portion if level is too high. See that breather is clean and functioning correctly.
	3. Overloading	
Oil leakage	1. Too much oil in unit	1. Recheck oil level with unit shut down.
	2. Clogged breather	2. Remove and clean breather.
	3. Loose bolts or nuts	3. Tighten all joint and end cap bolts.
Loosened mounting bolts	1. Usually vibration from fluctuating loads or misalignment	1. Check and re-align system. Tighten all bolts.

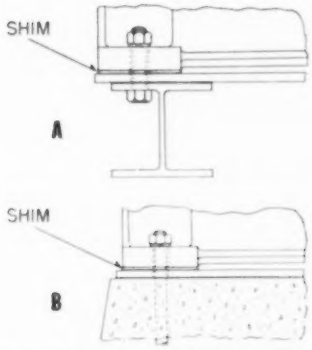
on level foundations. Applications requiring the use of units on angle mountings are always special and will require changes in the lubrication system. Contact manufacturer for detailed data before proceeding.

Electrical Connections

All motor leads are located in the conduit box on the side of the motor. Leads are tagged and identified to correspond with the wiring diagram engraved on the nameplate of each unit. All electrial connections should be installed in accordance with the National Electric Code and local requirements.

Common Causes of Trouble

If the gearmotor is driving the connected equipment through a sprocket, belt pulley or a pinion mounted on the output shaft of the gearmotor, the center of the face of such overhung member should be located at the center of the shaft extension of the gearmotor. For example, a pulley with a hub which allows the center of the face of the pulley to extend beyond the end of the output shaft of the gearmotor will create an excessive overhung load on the gearmotor's bearings if the unit is loaded to capacity.



Typical foundation details for gearmotor installation

If the gearmotor is connected to the driven equipment by a sprocket or chain drive, then the centerline of the two sprockets or pulleys should never be in the vertical plane but always in the horizontal plane. When driving in a vertical plane, the chain stretch permits the chain to slip over the teeth of the lower member. This will result in serious shock loads and may cause premature failure of both the gearmotor and the driven equipment.

When a pinion is mounted on the output shaft of the gearmotor for gear drive or connection to the driven equipment, the area of contact on the pinion teeth must be well distributed over the entire face width of the pinion and uniform from the outside to the inside of the pinion faces. The mesh of the pinion teeth with the mating gear teeth should be adjusted to permit lubrication without taking up the full amount of backlash.

Reflected Loads

The loads imposed upon a gearmotor when driving the driven equipment through such a connection are reflected back into the gearmotor. These loads are, of course, relative to the amount of load required to drive the driven equipment plus any abnormal load created by the grade of gearing or the accuracy of the pinion and gear.

It is important, when checking apparent noisy operation of a gearmotor, to investigate thoroughly the method of transmitting the load from the gearmotor to the driven equipment as well as the accuracy of the parts used.

Normal Operation

During normal operation, when the driving loads are within the designed capacity of the gearmotor, the temperature of the unit should never exceed 160 F. If it is, special operating instructions should be obtained from the manufacturer. When the operating temperature is greater than 160 F in ambient temperatures no greater than 140 F, some abnormal operating condition exists, and the gearmotor should be immediately checked for oil level and grade of lubricant. Amount of normal load should also be checked as well as the peak loads and the cycle of peak loads that are being transmitted by the unit or reflected in the unit by the driven equipment.

Outside Mounting

When the unit is mounted outside and is subject to wide variations in temperature and weather conditions, it may be necessary to remove the present breather from the gearmotor for replacement with a solid breather. This will prevent condensation which would eventually result in the emulsifying of the oil in the gearmotor.

FOR THE PLANT ELECTRICIAN

TESTING UNIDENTIFIED TRANSFORMERS FOR POLARITY

By MYRON C. ZIEMKE

THE PROBLEM involved three transformers with 2400-v primaries and 240-v secondaries with a capacity of 150 kva. Having a voltmeter at hand we used the following method to check the polarities:

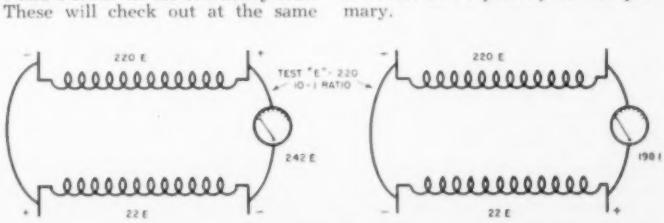
Since there are two primary and two secondary leads per transformer these leads were marked 1 to 6, looking toward the primary side. Also mark the leads left to right both primary and secondary. Beginning with the 2400-v side tie leads 2 and 3 together, 4 and 5, and 1 and 6 together. Then connect the 240-v power supply to the ties between transformers, or at 1-2-4.

Now, with the secondary leads segregated and after clipping the 240-v supply to the primary, take readings across 1 and 2, 3 and 4, and 4 and 6 leads on the secondary side. These will check out at the same value providing the transformers have similar characteristics and are correct as to ratio. Now tie 2 and 3 together, also 4 and 5 as we did on the primary side, yet we leave 1 and 6 open. With the volt meter across 1 and 6 if we have proceeded correctly so far the reading should be zero. Leads 1 and 6 may then be connected. The load is then applied reading will be zero across the final tie.

An Alternative Method

Connect primary winding to the 200-v supply. Connect one lead of the primary winding to one lead of the secondary winding, test with a voltmeter between the other terminal of the primary winding and the secondary. If reading is test E plus secondary E, the terminal is of opposite polarity as that of the primary terminal.

If the voltmeter reading is test E minus, secondary E, the terminal is of the same polarity as the primary.



Diagrams showing method of determining correct polarities

Shortcut For Determining Induction Motor HP

A helpful maintenance hint from the Industrial Department of the General Electric Company

WITH THE accelerated pace of industrial activity, many machines and factories are now working around the clock. This means in many instances that some machines are being loaded with heavier production schedules than they were originally designed for, while others are underloaded. Too, the great demands for new machinery have led to the installation of much used equipment which in many cases is overmotored in relation to the immediate job.

It is a well-known fact that underloaded induction motors operate at very poor power factor and draw an excessive amount of lagging current. This in turn wastes vitally needed power in all feeders and in distribution equipment clear back to the generating station power.

Frequently these difficulties can be overcome by checking the load and, on the basis of such a check, switching motors on some of the machines to improve the load factor. The purpose of this article is to present a simple method whereby loading on integral-horsepower induction motors can be determined with practical accuracy by means of a hook-on volt-ammeter.

This method is of unknown origin but has been used with practical results by several plant electricians for a number of years, and has been checked for accuracy with design data of motors. With this method it is not necessary to lose productive time, because the leads to the motor need not be disconnected to make the tests.

Here are the seven simple steps to be taken in using this method:

1. Plot a chart with "% hp" against "% full-load amperes" for each motor.

2. Locate point A as 100 per cent from motor nameplate reading of amperes at rated hp of motor. (Also it is assumed that the nameplate voltage is maintained.)

3. Disconnect motor from load and read no-load amperes with ammeter and locate point C in per cent of full-load current (approximately 25 to 45 per cent depending on speed of motor).

4. Locate point D halfway between O and C and draw line DA.

5. Locate point B on line DA at 50 per cent of the motor hp rating and draw CB.

6. Then line ABC will be the approximate curve of the per cent horsepower output of the motor plotted against per cent of motor current.

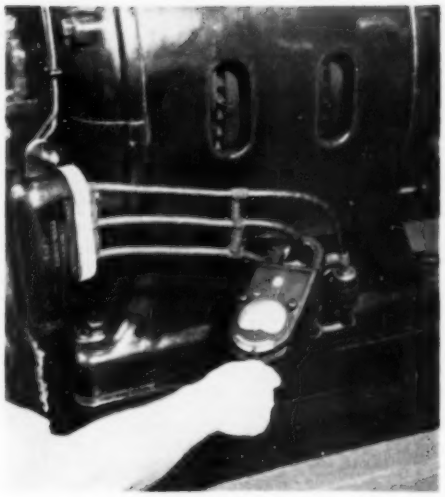


Fig. 2. This photograph shows how the Hook-on Volt-ammeter is used to measure motor current. Simply clamp the jaws around one of the leads to the motor and read the current

7. For any motor current, read in amperes, calculate the percentage of the full-load current, follow horizontally until line ABC is intersected. Then drop down vertically and read the per cent load of the rated hp of the motor.

If it is not convenient or feasible to disconnect the motor from the load as suggested in Step 3, then the no-load current can be taken from Fig. 1. For example, an 1800-rpm motor has a no-load current of approximately 25 per cent which is the average for motors up to 100 hp. Lower speed motors have higher no-load currents, in the order of 45 per cent of full-load current for 600-rpm motors.

It may be surprising to find that the no-load currents are as high as that shown in Fig. 1, but it should be remembered that the no-load current is nearly all magnetizing current at practically zero lagging power factor and that the actual horsepower input from the power system is very low. This accounts

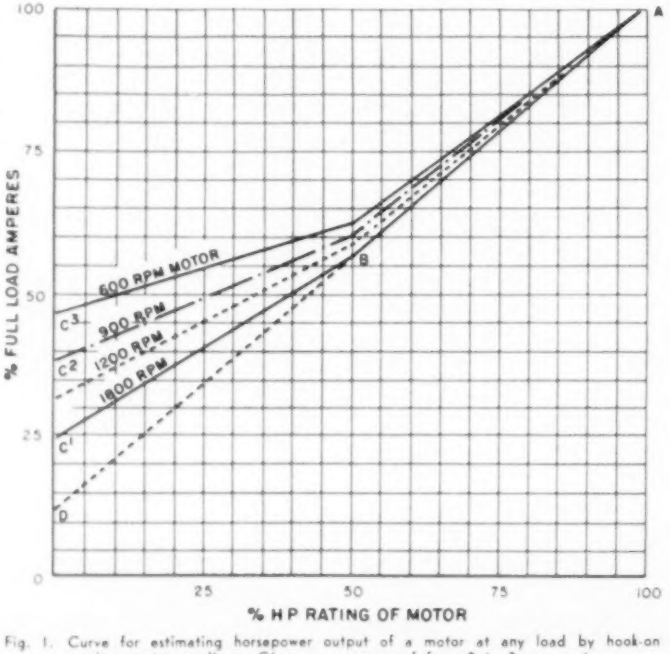


Fig. 1. Curve for estimating horsepower output of a motor at any load by hook-on volt-ammeter readings. Gives an accuracy of from 2 to 3 per cent

for the rather high currents below one-half load where the efficiency of the motor is also lower.

From one-half to full load, it can be seen that the motor current is roughly proportional to horsepower output because both efficiency and power factor are higher and more nearly constant.

Thus we have a timely, practical, and time-saving way to determine the horsepower that an a-c motor is delivering just from an ammeter reading. Accuracy of between 2 and 3 per cent can be expected, subject of course to the ammeter accuracy tolerance.

Another advantage to be obtained by the hook-on volt-ammeter is that the voltage applied to the motor can be read simultaneously with the current. It is obvious that a motor must have the proper voltage applied or the current will be too high and overheating will result. This will also give an indication of the loads on feeder copper so that remedies can be applied.

PRACTICAL HINTS AND KINKS

CLIP KEEPS FLUORESCENT TUBES FROM FALLING

By RICHARD ALLEN

No longer need falling fluorescent tubes cause injury, accidents or work interruptions. All of this is eliminated by the use of a new safety clip which holds fluorescent tubes in place regardless of the amount of vibration to which they are subjected. We're installing these safety clips around our plant after several experiences with the shock and noise occasioned by a falling and broken tube, and the clips are doing the job we wanted done.

The clips are made of resilient stainless steel, and are permanently installed by simply tightening the nut on a precision-made machine screw. Two safety clips are required for each tube, and since they cost only 35 cents a pair, they are really economical protection against falling glass and possible serious injury.

HOW TO REPAIR HOLES IN CONCRETE FLOORS

By ROBERT GILLIFORD

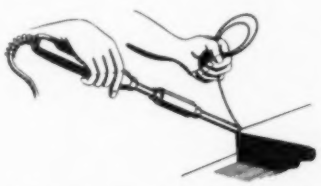
Even the best laid concrete floor will in time become worn and broken through constant use. This is particularly the case in garages and warehouses where motor vehicles or material trucks constantly pass over the floors. Such worn and broken places are hazardous to workers and may cause jars and jolts that may damage trucks and equipment. They also greatly detract from the general appearance of the building.

This condition need not be tolerated, since holes and ruts in the damaged floors can be easily repaired by means of a floor patching mixture known as Stonhard. No preliminary mixing or preparation is required. All that is necessary is to clean out dirt and dust from the hole or rut, place the patching material in the opening, and then tamp or roll down until a flush patch results. The floor is immediately ready for use, even under the heaviest traffic.

PERMANENT TINNING OF SOLDERING IRON TIPS

By JAMES BOYD

Here's a timely tip that may help you minimize the time consuming task of renewing the tinning on a soldering iron tip at regular intervals. This time saver requires the use of silver solder instead of ordinary solder for tinning the copper tip of the iron. Silver solder, due to its higher melting point, will not burn off at the usual operating temperatures of the iron, and will remain clean and bright for long periods of time.



Silver solder proves to be handy aid for tinning copper tip of the soldering iron

Application of the silver solder is simple. Simply follow the steps listed below:

(1) Remove the copper tip from the iron and clean it throughly to remove all scale and corrosion.

(2) File it to the desired shape with a mill file and then heat the tip with a blow torch until it is hot enough to flow silver solder onto. Use silver solder flux to facilitate the flowing operation.

(3) After the tip is completely coated with the solder, allow it to cool and reinsert it in the soldering iron.

This method has proved its value to workers who must keep their soldering irons heated much of the time in order to have them ready for immediate use.

SAFETY RULES FOR ROPE USERS

By JOHN REYNOLDS

It has been truly said that nothing can cause an accident faster than a careless driver or a rope that's been handled improperly. We'll let the drivers alone in this little article, but here are a few precautions worth observing when you're handling rope in construction and maintenance work:

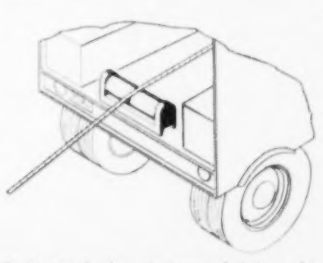
(1) Know how to make all knots required in your work. The wrong kind of knot or an incorrectly made knot may fail under stress and cause a serious accident. Be sure to leave enough rope end when making a knot so that it will not pull out when tightened.

(2) Remember that overloading rope will cause it to lose its strength. Sudden stresses or repeated stresses have the same effect. Use the right size of rope for the job and apply the load gradually, never with sudden jerks.

(3) Acquire the habit of examining rope for wear and defects before using it. Look for external evidence of abrasion, cuts, decay or burns. Open up the rope strand every three or four feet and note if broken fibers, mildew, powdery dust, or unusual color of fibers are present. If extensive defects are found, it is best to throw the rope away. Rope that has become very soft, or has lost its stretch is dangerous to use.

(4) Don't let rope get twisted or kinked. Turn out kinks before the load is applied. Even under light loads, a kinked rope will be greatly weakened or will break.

(5) Avoid spilling chemicals, paraffin, or molten solder on ropes. Battery acid will quickly render rope unfit for use.



Don't stand close to rope that is under tension

(6) Never store rope that has become wet. Coil the rope loosely on pegs and do not place it in storage until it is thoroughly dry. Avoid draping rope on steam radiators as too rapid drying will damage it, and be sure the room is dry and well ventilated.

(7) When using rope blocks, be sure there are no sharp edges or nicks on the sheaves to abrade or cut the rope. Don't let the rope get out of the sheaves and rub on stationary parts of the blocks. Be certain the blocks are of the right size for the rope used. Sheaves that are too small will cause excessive wear on the rope.

(8) Do not stand close to rope that is under tension. Avoid getting in the way of rope that may suddenly straighten out. Be careful not too catch your hand in rope being taken upwards or being snubbed around a fixed support.

(9) Wear gloves when handling rope to protect your hands from hard fibers.

HOW TO USE A FILE

By W. B. KENNEDY

Do you know how to use a file? Or do you just think you know? "Oh, anybody can use a file!" you will reply; but when I say "how," I mean using a file in the most effective manner possible; doing work as quickly as possible, and at the same time prolonging the useful life of the file, as well as saving the operator's sweat.

I have learned from experience and observation that most unexperienced filers push files diagonally to the right, and some workmen of considerable experience make the same mistake. This results in clogging the cutters of files cut in the usual manner. When pushed diagonally to the right, the cutters move squarely against the material being filed, tending to clog, as there is no motion tending to push the chips either right or left out of the cutters.

In my opinion, the CORRECT method is to push standard-cut files diagonally to the left. When pushed in this direction, the cutters are so positioned that the chips cut tend to form spirals, and tend to escape from the cutters (or grooves) at the right-hand edge of the file—instead of clogging the cutters, as happens when the INCORRECT method is used. Try it out and see for yourself that a left-hand diagonal stroke cuts best and saves files.

The writer once suggested that a prominent file manufacturer cut some files opposite from the usual manner, or position the cutters at an angle in the opposite direction. The manufacturer had a dozen files cut in the manner suggested, handed them to a dozen experienced filers to try out—without explaining that they were different. Only one man out of the dozen approved the change. They were all *experienced* men, note. If you have been using the incorrect method, you can save time, files, and sweat by switching to the correct one described above.

COMMON PLANT TROUBLES

By W. B. McCOOL

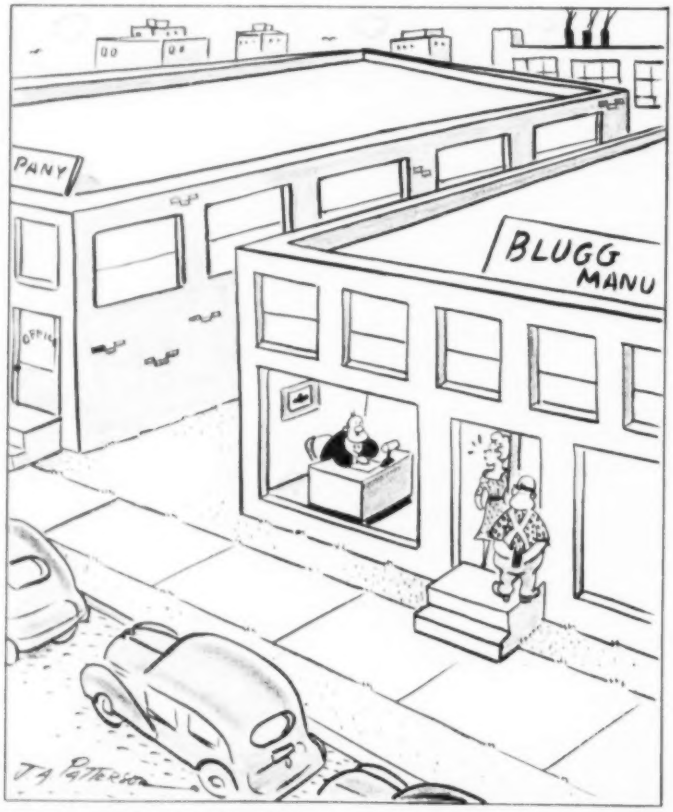
I VISITED A WOODWORKING establishment recently where lumber is dressed and boxes are manufactured.

"What troubles have you had and how did you correct them?" I asked the superintendent.

"Our worst mechanical trouble has been keeping our steam engines in shape. The original installations were too small for the load. As a result, we were continually having breakdowns. After several expensive repair bills, as well as loss of time and business, we decided to put in heavier engines. Bitter experience has taught us it is cheaper in the long run to have an excess of power than it is to try to run a plant with insufficient power. We had plenty boiler power from the start, but you can't keep an engine going when it is overloaded. Like some other operators I have known, we tried to substitute *speed* for power, but it just didn't work. It is highly important that one should have sufficient power at the outset (and some to spare for peak loads where there is a variation in the amount required) to avoid expensive breakdowns, loss of time, and consequent loss of money. We had to raise a fuss with the executives, however, and call in an experienced steam engineer before we got the changes made," the superintendent concluded on this subject.

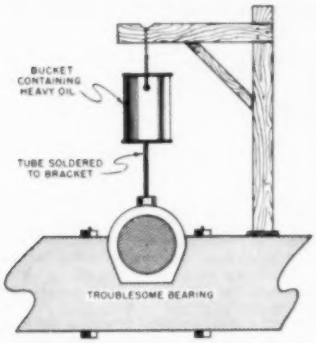
(They should have consulted a steam engineer in making the original installations; it would have been much cheaper in the long run.)

"Our next mistake was made in failing to put screens on top of our smoke stacks. The result was that burning shavings fell from a stack, landed in our shavings room, and burned it to the ground. After this happened, we put screens on the stacks to minimize the danger of fire being spread by falling shavings.



He's our next door neighbor—they ran short on atomic fuel. They want to borrow 1/2 ounce to tide them over the week-end!

This is another case where it would have been considerably cheaper to install the proper equipment at the outset than at a later date, after considerable damage had been done;



Scheme for keeping a hot bearing going by allowing heavy oil to trickle through a small tube soldered in the bottom of a can suspended above the bearing

which reminds us of the saying: 'Put it on, don't put it off!' "

"And again, we had trouble with our boiler flues when we allowed ashes and lye to wash into our pond supplying water to our boilers. The water was pumped from a deep well and was free of troublesome minerals, but we had to renew our flues too often until we built a concrete vat in which to store our boiler water to assure its freedom from lye, resin, or other chemicals resulting from the decomposition of shavings, sawdust, or other accumulations around the plant. Premature flue failure cost us more than enough to have built a water vat at the outset, not considering the loss of time, etc., occasioned by the shutdown while making the replacement."

"Occasionally, we have bearing trouble. If we think we can't afford to shut down for a repair on account of a rush order (or for other reasons) we usually manage to keep a hot bearing going by allowing heavy oil to trickle through a small tube soldered in the bottom of a bucket or can suspended above the bearing. This usually keeps us going until we can re-run or adjust the bearing."

See the accompanying sketch. The size of tube chosen should be such that the oil or grease will not flow too freely—even under the influence of heat—to avoid waste. Wire may be tied to a girder when a post isn't handy.

PORTABLE DRILL ATTACHMENT SPEEDS RIVET EXTRACTION

By F. E. RILEY
London, England

THE STANDARD methods of dismantling riveted structures consist of burning off the rivet heads with a gas torch or knocking them off with a cold chisel. Both methods cause considerable damage to the metal surrounding the rivets. Wanting to dismantle a riveted structure without causing very much damage to components from which it was made, I decided to drill out the rivets, a method which removes the fastenings with a minimum of brute force and leaves a clean hole for subsequent re-riveting or bolting.

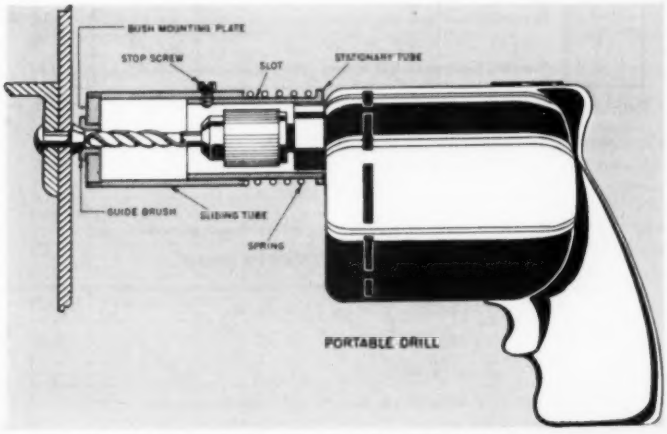
To ensure that the rivet shank shall be reduced to chips during the drilling, it is essential to start the the drill dead in the centre of the rivet head and to ensure this, the portable drill attachment shown in the sketch was made up.

It consists of a centering bushing attached to a telescopic body made up from a pair of steel tubes. The stationary tube is a stiff push fit on the diameter just behind the chuck on the portable drill casing, the sliding tube being urged forward by a compression spring so that pressure applied to the portable drill will be transmitted to the guide bushing and hold it in contact with the rivet head.

The guide bushing should be of hardened steel and arranged so that it can be pressed out of its mounting plate in order that other bushings to suit alternative sizes of rivet head may be substituted. A conical recess in the guide bushing, will accommodate a range of sizes and shapes of rivet head but the guide hole for the drill should equal the drill diameter.

To prevent the sliding and stationary tubes from falling apart, a stop screw fitting a tapped hole in the sliding tube engages with a slot cut in the stationary tube. By tapping several holes in the sliding tube, the telescopic assembly can be adjusted for length to suit various drill lengths.

Hundreds of rivets have been drilled out with this tool. If the drill is kept sharp, I consider it to be a slicker and cleaner method of removing rivets than any other.



Scheme for removing rivets by means of a portable electric drill

HOW THEY MOVED THE AIR COMPRESSOR

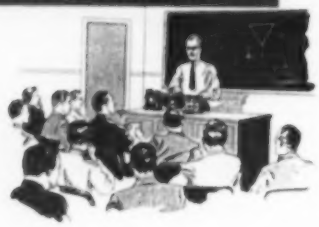
By H. B. McDERMID

IN AN ENGINE room which housed among other units an air compressor which though seriously overloaded was still in excellent running condition, it was decided to increase compressor capacity by installing a larger unit, while retaining the older unit for a spare. The engineer's problem in making the addition was to find room for the new machine, and to get the changeover made with no interruption to compressed air service about the shop.

The first compressor had been so set that its successor could not be placed without moving the earlier one; however, if it could be moved sidewise a little more than its width, so as to leave a service aisle between the two, the new machine could be placed in the approximate space and aisles in the location that the existing compressor now occupied. Since the first machine's foundation was too small for the second and larger machine, the normal method would have been to move the older machine to another previously prepared foundation just like the existing one, get the unit ready for service as fast as possible, then wreck its existing foundation, excavate for and place the larger foundation for the new unit, after which the new unit could be installed to take over the load.

After considerable study, the engineer came up with this method: first, while the old unit stayed in service, he excavated beside it for

(Continued on page 84)



Basic Power Plant FIGURING

A Review for Old-Timers

A Must for Young-Timers

By WILLIAM H. ENGELMAN
Mechanical Engineer
Department of Water & Light
City of Cleveland, Ohio

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Calculations and Data for Electrically-Driven Water Pumps—How to Find Water Horsepower, Motor Kilowatts, Pumping Cost

WHEN YOU have to calculate the power required and the costs of pumping water with motor-driven pumps, here is the way to do it. The first thing to do is find the water horsepower, which is: Number ft lb of energy expended in raising the required quantity of water, in a specified time to the desired height or against the given pressure ÷ number of ft lb in one horsepower or

$$\text{Water hp} = \frac{\text{Lb water per min} \times \text{head in ft}}{33{,}000 \text{ (the ft lb per min in 1 hp)}}$$

If the original head against which the water is to be raised is given in feet, that's easy. But if it is given in psi, then you must convert to feet head by using 2.31 ft head = 1 lb per sq in. pressure. That is: 500 psi = 500 × 2.31 = 1252 ft head. The other way, 1000 ft head = 1000 ÷ 2.31 = 433 psi. For accurate calculations, friction losses in pipe and fittings must be converted to feet head and included in total head.

The water horsepower must be found first, after which you can find the pump brake horsepower or shaft horsepower, which depends solely on the pump efficiency.

The head, against which the pump operates, can either be calculated, or may be read directly from a pressure gage. The gage reading may give the total head in feet, or, if the reading is in pounds pressure, the multiplier 2.31 is used to obtain the feet-head, since 1 psi equals a column of water 2.31 ft high which in turn gives 0.433 psi for a column 1 foot high. With the gpm and the head known, the theoretical horsepower, generally known as water horsepower, can be computed as follows:

$$\text{Water Hp} = \frac{\text{gpm} \times \text{head in feet} \times 8.33 \text{ lb per gal}}{33{,}000}$$

$$\text{Actual Hp} = \frac{\text{gpm} \times \text{head in feet} \times 8.33 \text{ lb per gal}}{33{,}000 \times \text{pump efficiency}}$$

Note: In this formula the efficiency is always expressed as a decimal; that is, less than 1.0.

When the pumpage is given in gpd:

$$\text{Water Hp} = \frac{\text{gpd} \times \text{head in feet} \times 8.33 \text{ lb per gal.}}{24 \times 60 \times 33{,}000}$$

$$\text{Actual Hp} = \frac{\text{gpd} \times \text{head in feet} \times 8.33 \text{ lb per gal.}}{24 \times 60 \times 33{,}000 \times \text{pump efficiency}}$$

Using this formula for the example under Table II:

$$\text{Actual Hp is } \frac{12{,}000{,}000 \times 150 \times 8.33}{24 \times 1{,}980{,}000 \times 0.90} = 350.6 \text{ hp}$$

Extreme care must be taken in the use of numerical values since the volume of water to be delivered may be given in pounds, gallons, or cubic feet; and also with the time involved, whether seconds, minutes, hours, or a day of 24 hours is used.

Very often the discharge of a pump is given in cubic feet, this amount multiplied by 7.48 gives the discharge in gallons. With large pumping units, such as used in water works and pumping stations, the capacity is expressed in million gallons per day, abbreviated mgd.

Capacity of boiler feed pumps is commonly given in pounds per hour (steam generating capacity of boiler), but here, the conversion factor to gallons must also be corrected for temperature. Water at 32 F weighs 8.344 lb per gal; at 39.2 F—8.345 lb per gal, (point of maximum density); at 212 F—7.998 lb per gal; at 320 F—7.575 lb per gal; at 392 F—7.2 lb per gal. With the open type feedwater heater operating at 200 to 220 F, a value of 8 lb water per gallon is usually considered reasonable. For accurate values at any temperature, consult Keenan & Keyes Steam Tables for volume and density of water, Table 1, Saturation, Temperatures.

Note: In some cases, you may find quantities of water expressed in acre feet; this unit is sometimes used in irrigation work and in expressing pondage, run-off or other data used in hydraulic work. 1 acre foot means an acre covered with water 1 ft deep and since an acre is 43,560 sq ft, 1 acre-foot = 43,560 cu ft. To convert this into gallons multiply it by 7.48, into pounds, by 62.4.

Here are two examples calculated to show how the electric power and the pumping costs can be calculated. Problem 1 is graphed on the chart, page 83, with instructions for getting the answer. Following that you will find horsepower tables for pumping at various heads and efficiencies.

Boiler feed pumps usually operate at heads much higher than shown here but the actual power and costs can be calculated just as easily by the same formulas, once you have the water horsepower, the pump efficiency, the motor efficiency and the unit cost of power.

(Continued on page 84)

Item	Data Given or Found	Problem 1 (See Chart)	Problem 2
* A	Gallons pumped per minute (GPM)	1,400	700
* B	Head in Feet	150	50
C	Water Horsepower, (theoretical Hp)	53	9
* D	Pump Efficiency, per cent	83	60
E	Brake Horsepower, (shaft Hp)	64	15
* F	Motor Efficiency, per cent	92	70
G	Motor Kilowatts	52	16
* H	Power Costs—Cents per kwhr	1.5	3.0
I	Pumping Cost—Cents per hour	78	48
J	Pumping Cost per 1,000 gallons, cents	.93	1.14

Note: Items marked * are usually known or given, from which others can be found, thus

C $\frac{1{,}400 \times 8.33 \times 150}{33{,}000} = 53$ Water Hp.

E $53 \div 0.83 = 64$ Brake Hp.

G $\frac{64 \times 0.746}{0.92} = 52$ Kw

I $52 \times 1.5 = 78$ cents per hour, or 1.3 cents per minute

J $\frac{1.3 \times 1{,}000}{1{,}400} = 0.93$ cents per 1,000 gallons pumped

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C $\frac{700 \times 8.33 \times 50}{33{,}000} = 8.84$, use 9.0 Water Hp.

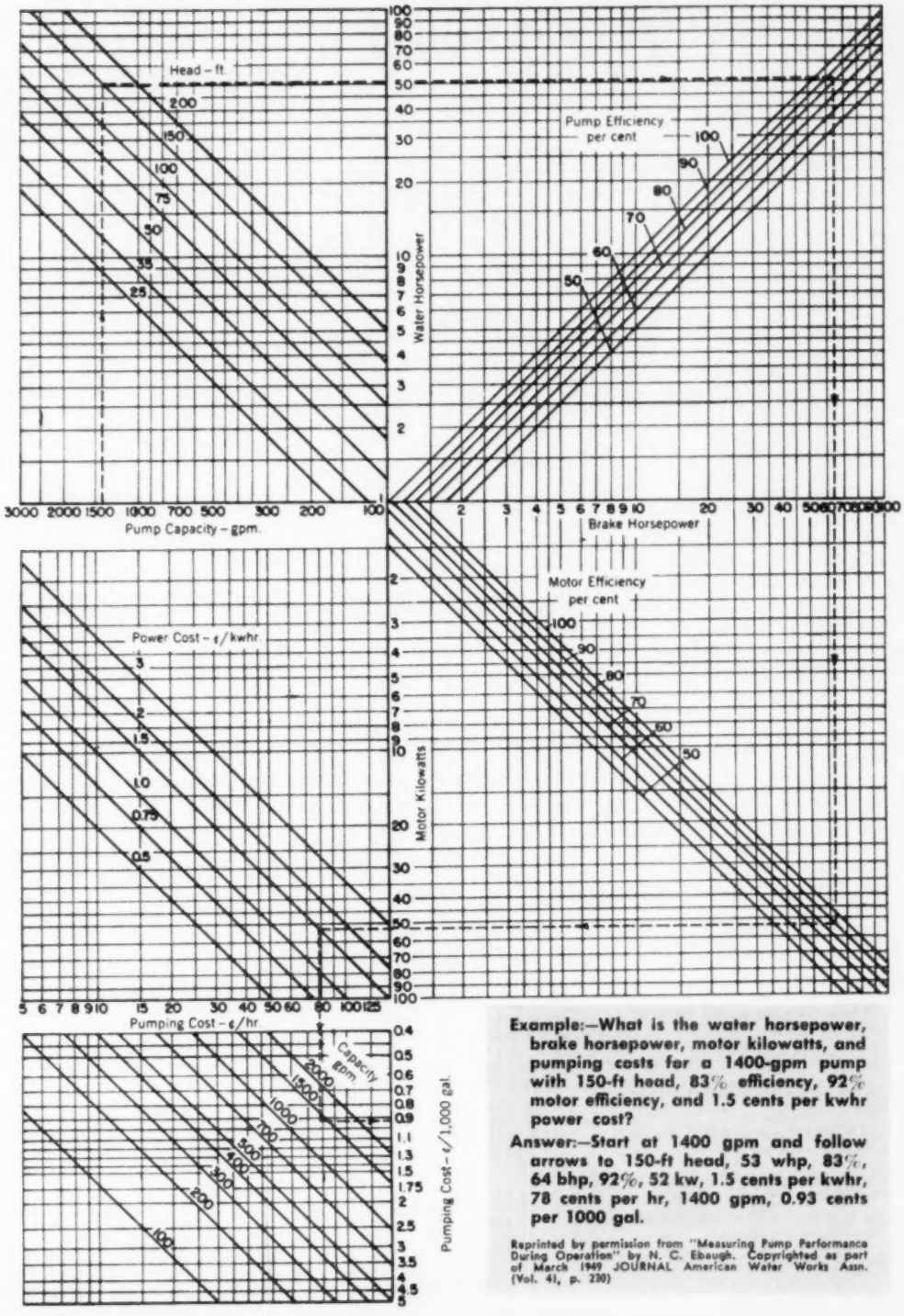
E $9.0 \div 0.6 = 15$ Brake Hp.

G $\frac{15 \times 0.746}{0.70} = 16$ Kw.

I $16 \times 3 = 48$ cents per hour, or 0.8 cents per minute.

J $\frac{0.8 \times 1{,}000}{700} = 1.14$ cents per 1,000 gal pumped.

Chart for Estimating Pump Horsepower, Kilowatts, and Pumping Costs



Example:—What is the water horsepower, brake horsepower, motor kilowatts, and pumping costs for a 1400-gpm pump with 150-ft head, 83% efficiency, 92% motor efficiency, and 1.5 cents per kwhr power cost?

Answer:—Start at 1400 gpm and follow arrows to 150-ft head, 53 whp, 83%, 64 bhp, 92%, 52 kw, 1.5 cents per kwhr, 78 cents per hr, 1400 gpm, 0.93 cents per 1000 gal.

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BASIC POWER PLANT FIGURING

(Continued from page 82)

TABLE I. Actual horsepower required to raise 100 gpm of water to various heights at various pump efficiencies. 1 gal weighs 8.33 lb

Eff'y per cent	ELEVATIONS IN FEET								
	50	75	100	125	150	175	200	225	250
	ACTUAL HORSEPOWER								
60	2.104	3.155	4.20707	5.259	6.311	7.362	8.414	9.466	10.518
62	2.036	3.054	4.07136	5.089	6.107	7.125	8.143	9.161	10.178
64	1.972	2.958	3.94413	4.930	5.916	6.902	7.888	8.874	9.860
66	1.912	2.868	3.82461	4.781	5.737	6.693	7.649	8.605	9.562
68	1.856	2.784	3.71212	4.640	5.568	6.496	7.424	8.352	9.280
70	1.803	2.705	3.60606	4.508	5.409	6.311	7.212	8.114	9.015
72	1.753	2.629	3.50590	4.382	5.259	6.135	7.012	7.888	8.765
74	1.706	2.558	3.41114	4.264	5.117	5.970	6.822	7.675	8.528
76	1.661	2.491	3.32137	4.152	4.982	5.812	6.643	7.473	8.303
78	1.618	2.427	3.23621	4.045	4.854	5.663	6.472	7.281	8.091
80	1.578	2.366	3.15530	3.944	4.733	5.522	6.311	7.100	7.888
82	1.539	2.309	3.07834	3.848	4.618	5.387	6.157	6.926	7.696
84	1.503	2.254	3.00505	3.756	4.508	5.259	6.010	6.761	7.513
86	1.468	2.201	2.93517	3.669	4.403	5.137	5.870	6.604	7.338
88	1.434	2.151	2.86846	3.586	4.303	5.020	5.737	6.454	7.171
90	1.402	2.104	2.80471	3.506	4.207	4.908	5.610	6.311	7.012
92	1.372	2.058	2.74374	3.430	4.116	4.802	5.488	6.173	6.860
94	1.343	2.014	2.68536	3.357	4.028	4.700	5.371	6.042	6.713
96	1.315	1.972	2.62942	3.287	3.944	4.601	5.259	5.916	6.574
98	1.288	1.932	2.57575	3.220	3.864	4.508	5.152	5.795	6.440
100	1.262	1.893	2.52424	3.155	3.786	4.417	5.049	5.680	6.311

Here's how Table I values were computed:

A pump delivers 100 gpm, total head 100 ft, pump efficiency 72%.

What is the work done in foot-pounds per minute, the water hp developed, and the actual hp or shaft hp at the pump?

100 gpm at 8.33 lb per gal is 833 lb of water per minute.

Work done: 833 × 100 is 83,300 ft-lb per minute.

Water hp: 83,300 ÷ 33,000 is 2.52424, at 100 per cent eff.

Actual hp: 2.52424 ÷ 0.72 is 3.506 shaft hp., see table.

In the problem if the total head is 225 ft and the pump efficiency 80 per cent, the actual hp would be 7.10.

With a total head of 450 ft and the pump efficiency at 80 per cent, the actual hp would be 7.10 × 2 or 14.2 hp.

For values not given in table, use an even multiple, for instance, value for 400 gal is 4 times the value for 100 gal given in table.

Derivation of the values in Table II is as follows:

1 mgd is 694.444 gpm at 8.33 lb per gal is 5,784.72 lb water per min.

Work done: 5,784.72 × 100 is 578,472 ft lb per minute.

Water Hp: 578,472 ÷ 33,000 is 17.5295 at 100 per cent eff., see table.

Actual Hp at 84% eff. is 20.8685 or 20.87.

At 12 mgd, 150 ft. hd. and 90% eff. we have 29.22 × 12 is 350.6 Hp.

TABLE II. Actual horsepower required to raise 1,000,000 gal of water per day, or 1 mgd, to various heights at various pump efficiencies. 1 gal weighs 8.33 lb

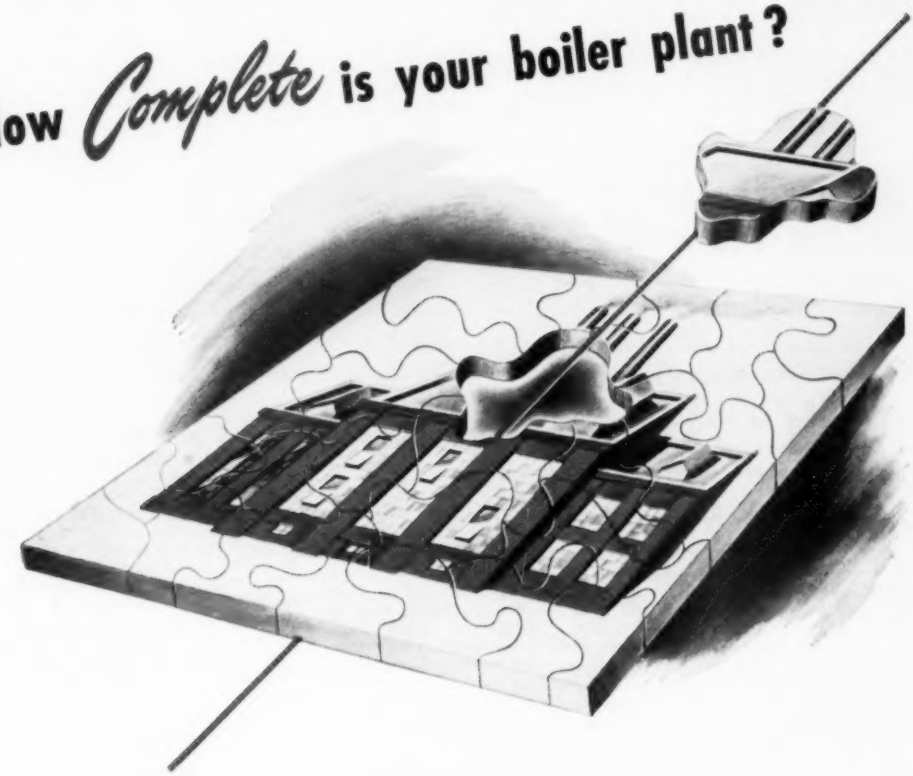
Eff'y per cent	ELEVATIONS IN FEET								
	50	75	100	125	150	175	200	225	250
	ACTUAL HORSEPOWER								
70	12.52	18.78	25.0421	31.30	37.56	43.82	50.08	56.35	62.61
71	12.35	18.52	24.6894	30.86	37.03	43.21	49.38	55.55	61.73
72	12.17	18.26	24.3465	30.43	36.52	42.61	48.69	54.78	60.87
73	12.01	18.01	24.0130	30.02	36.02	42.02	48.03	54.03	60.03
74	11.84	17.77	23.6885	29.61	35.53	41.46	47.38	53.30	59.22
75	11.69	17.53	23.3727	29.22	35.06	40.90	46.75	52.59	58.43
76	11.53	17.30	23.0651	28.83	34.60	40.36	46.13	51.90	57.66
77	11.38	17.07	22.7656	28.46	34.15	39.84	45.53	51.22	56.91
78	11.24	16.86	22.4737	28.09	33.71	39.33	44.95	50.57	56.18
79	11.10	16.64	22.1892	27.74	33.28	38.83	44.38	49.93	55.47
80	10.96	16.43	21.9119	27.39	32.87	38.35	43.82	49.30	54.78
81	10.82	16.23	21.6414	27.05	32.46	37.87	43.28	48.69	54.10
82	10.69	16.03	21.3774	26.72	32.07	37.41	42.76	48.10	53.44
83	10.56	15.84	21.1199	26.40	31.68	36.96	42.24	47.52	52.80
84	10.43	15.65	20.8685	26.09	31.30	36.53	41.74	46.95	52.17
85	10.31	15.47	20.6229	25.78	30.93	36.09	41.25	46.40	51.56
86	10.19	15.29	20.3831	25.48	30.58	35.67	40.77	45.86	50.96
87	10.07	15.11	20.1489	25.19	30.22	35.26	40.30	45.34	50.37
88	9.96	14.94	19.9200	24.90	29.88	34.86	39.84	44.82	49.80
89	9.85	14.77	19.6961	24.62	29.54	34.47	39.39	44.32	49.24
90	9.74	14.61	19.4772	24.35	29.22	34.09	38.95	43.82	48.69
91	9.63	14.45	19.2632	24.08	28.90	33.71	38.52	43.34	48.16
92	9.53	14.29	19.0538	23.82	28.58	33.34	38.11	42.87	47.64
93	9.42	14.14	18.8489	23.56	28.27	32.99	37.70	42.41	47.12
94	9.32	13.99	18.6484	23.31	27.97	32.64	37.30	41.96	46.62
95	9.23	13.84	18.4521	23.07	27.68	32.29	36.94	41.52	46.13
96	9.13	13.70	18.2600	22.83	27.39	31.96	36.52	41.09	45.65
97	9.04	13.55	18.0716	22.59	27.11	31.63	36.14	40.66	45.18
98	8.94	13.42	17.8872	22.36	26.83	31.30	35.77	40.25	44.72
99	8.85	13.28	17.7066	22.13	26.56	30.99	35.41	39.84	44.27
100	8.77	13.15	17.5295	21.91	26.29	30.68	35.06	39.44	43.82

HOW THEY MOVED THE AIR COMPRESSOR

(Continued from page 81)

a new foundation space, and also dug all around it, to free it from the clay it set in; then he drove scrap pipe under the old foundation, as near horizontally as possible, from the side toward which the unit was to move, to form a surface upon which the foundation could slide easily. To further this effect, he wet down the bottom of the new pit, so that any concrete irregularities would move through it easily. Then he hitched two heavy chain falls onto the foundation block, and set heavy jacks behind it. When the week end came, he disconnected all pipes, etc., and manned the jacks and chain falls. The block, some seven feet square and four deep, resisted heavily at first, but once broken loose, came along nicely, bringing with it of course, the air compresser which was mounted on it. Arrived at location, he had but to level block and all, cut new closure pieces for his piping, and the old unit was ready to go with the minimum of "outage" time. Now the space was cleared for the new machine, and its foundation and the

How *Complete* is your boiler plant?



Insofar as mechanical equipment is concerned, a boiler plant may be complete in every respect. However, completeness of equipment will not necessarily assure most efficient operation of the system. An adequate and well controlled program of boiler water treatment, too, is highly important. A water conditioning engineering service should be an integral part of your picture. We ask, "how *complete* is your boiler plant?"

W. H. & L. D. BETZ is an organization of engineers and chemists specializing in the solution of all industrial water conditioning problems relative to boiler feedwater . . . cooling water . . . air conditioning . . . industrial waste treatment. Years of experience have made Betz water conditioning service scientifically correct . . . complete . . . economical. Whatever your particular water conditioning requirements, our staff of engineers is ready to serve you. W. H. & L. D. BETZ, Gillingham and Worth Streets, Philadelphia 24, Pa. In Canada—BETZ Laboratories Limited, Montreal 1.

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new machine could be placed at leisure, without troubling anyone in the production end of the company. His excavation costs were not perceptibly increased. He had saved the cost and time required to wreck the old foundation, and form up and pour a new one—something which could not be done without seriously curtailing service — and he had moved his old machine without any one depending on it being any the wiser, and had also made room for the new machine so that it could go in without any interference with anyone.

So, his stunt, though unorthodox, served his purpose well—perhaps the experience may be useful to others.

Grades and Types of Industrial Fuel Oils

This is the second of several articles by Mr. Schmidt on the characteristics of fuel oils. The first in last month's issue described various methods of refining oils. Here, he describes the various types of fuel oils. A subsequent article will deal with the meaning of Gravity in connection with fuel oil

By PAUL F. SCHMIDT

Allied Oil Company, Inc. Cleveland, Ohio

AS THERE are many types of burners used in many different operations, from open hearths to small hot water heaters, so must there be different grades of fuel oil to meet their needs. Some burners can burn all grades of oils, while others are sensitive to one particular grade. The burners that can operate on all or more than one grade of fuel oil, usually cannot do so economically with every grade. With some grades their consumption increases because the oil is too light, and with less heat content, while if the grade of oil is too heavy, poor combustion results.

Selection of Proper Grade

The proper grade of oil for any installation is usually governed by the following points.

1. Type and size of burner. Burners for light oils have small openings in their burner tips, and burners with large openings use heavier oils.

2. Type and method of atomizing. Some installations use low pressures of air and steam, while some use high pressures of air and steam. Mechanical burners can use different grades as light and medium, but with heavy oil, preheaters are necessary.

3. Size of combustion chamber. Some chambers are small and some large. Combustion chambers of boilers are usually large, and so are those in open hearths, while with heating furnaces in metal smelting shops they are small.

4. Type of equipment, such as size of fuel pumps, preheaters, and heating facilities in storage tanks.

5. Type of operation. Where it is necessary to have tremendous heat, it would be foolish to use a light oil with low heating value, such as in open hearths, or under large boilers, or heat treating furnaces. Small compact heating furnaces or ovens, such as used in the ceramic and porcelain industry, would need a light oil.

Sometimes the grade of fuel oil used is governed by the price. The consumer may try to use a heavier grade, due to its cheaper price. This is good economics, but it may lead into trouble, such as trying to use a too heavy oil in cold weather, without the proper heating facilities.

Four Grades of Industrial Fuel Oils

The four grades of industrial fuel oils, are plainly described as follows:

No. 2 fuel oil is called a distillate oil, as it is capable of being distilled or vaporized at normal temperatures and pressures. It is also called a gas oil.

No. 4 fuel oil is a blended oil, usually blended of grades No. 2, 5 and 6.

No. 5 and 6 fuel oils are the heavy black residuals.

It should be remembered that though we have only 4 basic grades, there are many variations, but they still retain the four original grade numbers.

According to the standardized specifications for fuel oils, there is no No. 3 grade. These specifications are new, being set forth in September, 1948, when the grade No. 3 was deleted, and grade No. 2 substituted. As the proper procedure is to use Grade No. 2, but due to habit and custom, some people still use No. 3, so to avoid confusion and misunderstanding, No. 2 and No. 3 can be accepted as meaning the same grade of oil.

Types of Fuel Oils

The four grades of oils can be composed of a number of different types. The type of an oil, is due to the method of refining it. These types of oils used as fuels industrially, are as follows: the first being used in the greatest volume, and diminishing as we go downward.

1. Cracked residuals—No. 5 and 6 oils
2. Straight run residuals—No. 5 and 6 oils
3. Cracked distillates—No. 2 oils
4. Straight run distillates—No. 2 oils
5. Blends of any of the above types
6. Crude Oils
7. Reclaimed fuel oils and lubricants

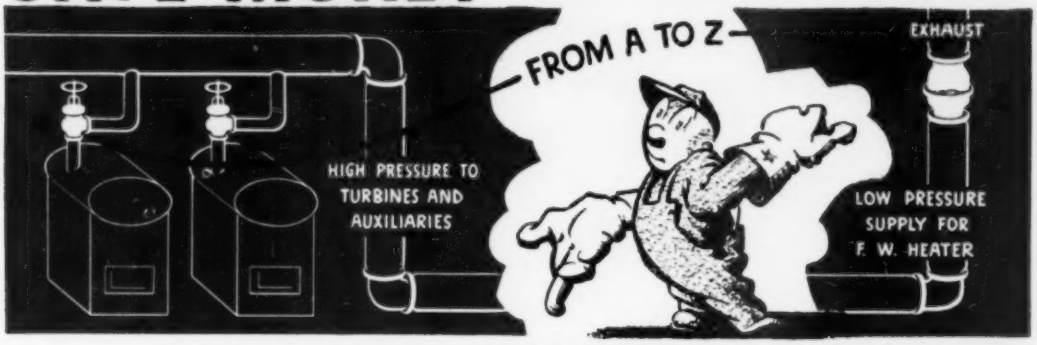
The use of reclaimed fuels is not practiced on a very large scale, but it is increasing slowly. The recent war gave impetus to these oils, due principally to the scarcity of regular fuel oils, and their high prices, which made profitable, the cleaning of contaminated oils.

These reclaimed fuel oils are those fuel oils, that have become contaminated with an unusual amount of water and sediment, such as tank bottoms. The emulsion, as it is called is treated by addition of heat or chemicals, thereby separating the good clean fuel oil from the impurities. The volume of this type is small, usually of good quality if purchased from reliable suppliers.

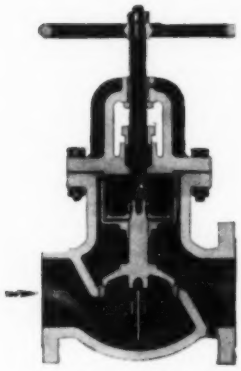
Reclaimed lubricants that are used as fuel oils, are generally crankcase drainings from automobiles, cutting, quenching, tempering oils, and material of this nature. The contaminates in this type of material, are usually sediment, plus a little water. As the sediment is generally very fine, it is harder to separate than the water, so that reclaimed lubricating oils are not as clean as reclaimed fuel oils, and have a number of other draw-backs in their use.

One of the principal reasons for buying reclaimed oils, is the difference in price between them and regular fuel oils. Though the price may be cheaper, so may the grade and quality of oil that is being purchased. Not all reclaimed oils are clean and free from dirt, grit, lint and water. Sometimes there is still considerable contamination in the oil, ranging from 2 to 10 per cent, and even higher. Besides buying and paying for non-combustible material, there is a danger of accumulating a large deposit of sludge in the storage tank, necessitating a costly clean-out job. Another problem that may result is clogged strainers and burner tips, causing shut-downs and loss of heat and production. An item frequently overlooked, is the fact that most reclaimed oils have a considerably

SAVE MONEY IN YOUR PLANT



—with FOSTER AUTOMATIC VALVES



FOSTER AUTOMATIC NON-RETURN Stop and Check Valve, Type 2

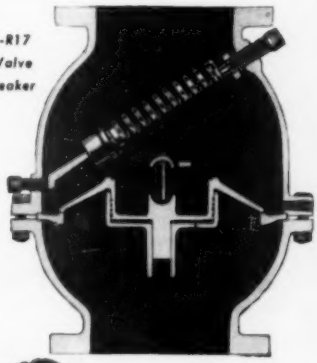
A . . . On your boiler drums, Foster Automatic Non-Return, Stop and Check Valves save money by doing their job perfectly—with the absolute minimum of attention—for years. It is not unusual to find these valves still giving good service after 25 or 30 years and more. Today's valves are even better.

There's nothing skimpy about a Foster Type 2. Full pipe area means negligible pressure drop across the valve. Heavy duty, through bolted construction makes it safe to work under when the boiler is down. Low pressure types to 250 lbs. (stocked) have semi-steel bodies, bronze trimmed, with stainless steel seat rings; high pressure types to 1,500 lbs. have cast steel bodies, trimmed with special heat resisting, corrosion resisting alloys. Piston chambers are renewable. They're built for lifetime service. Globe, angle, or elbow, from 2½" to 12".

Z . . . The R-17 Back Pressure Valve saves money by keeping the pressure where you want it on the exhaust side—for your feed water heater or other low pressure equipment—with a minimum of maintenance. Large pipe area, and large valve area mean low pressure drop across the valve, and sensitive action at low pressures. Saves make-up steam. Adjustable in ounces.

The R-17 has no outside stuffing boxes or external weights. Loading spring is on the atmosphere side of the valve and is accessible for inspection through a large handhole. Renewable seat ring and dash pot. 2½" to 20", (with sizes from 4" to 12" stocked).

Foster Type 34-R17 Back Pressure Valve and Vacuum Breaker



*** All along the line—Foster Pressure Regulators, Temperature Regulators, Pump Governors, Float Valves, Safety Valves, Check Valves, Relief Valves and Safety Valves are designed and built to save money, by giving reliable, trouble free regulation with a minimum of maintenance. When you select the proper Foster Valve and install it correctly, you are making a sound investment, backed by more than 70 years of practical experience in building good valves, and our reputation for service.

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PRESSURE REGULATORS . . . RELIEF AND BACK PRESSURE VALVES . . . CUSHION CHECK VALVES . . . ALTITUDE VALVES . . . FAN ENGINE REGULATORS . . . PUMP GOVERNORS . . . TEMPERATURE REGULATORS . . FLOAT AND LEVER BALANCED VALVES . . . NON-RETURN VALVES . . . VACUUM REGULATORS OR BREAKERS . . . STRAINERS . . . SAFETY VALVES . . . SIRENS

835 LEHIGH AVENUE • UNION, N. J.

Continuing Metallurgical Study Produces Major Savings For Utilities

BACK some ten years ago, Kellogg's metallurgists, working with the turbine manufacturers, discovered that carbon-moly steel, which had been "killed" with less than half a pound of aluminum per ton, could readily be heat-treated at lower temperature to achieve the desired uniform acicular grain size for optimum elevated temperature strength.

This was, naturally, important as the demand grew for piping to withstand operating temperatures up to 950° F. But even more important was the later discovery that this steel showed practically no graphitization at this temperature. As a matter of fact, when graphitization troubles hit the utility industry in general during the early forties, *Kellogg* carbon-moly installations using this steel were found to be unaffected. Obviously this meant a saving of hundreds of thousands of dollars for those utility companies that had followed Kellogg carbon-moly specifications.

Today, to prevent graphitization at even higher temperatures (up to 1050° F.) chrome-moly steels have been generally adopted by the industry for main steam piping.

Functioning in the same pattern as they did a decade ago, Kellogg's metallurgical groups are currently working toward pin-pointing the *minimum amount* of chromium that can be used successfully in high temperature piping.

Specific and continuing development work is one of the many advantages that utility companies gain when they specify M. W. Kellogg high temperature and high pressure piping.

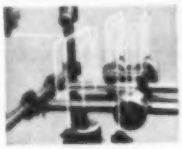
Illustrated — photomicrograph (500 m.) of specimen indicating presence of graphitization.

To make high pressure and pressure use piping and pressure equipment

M. W. KELLOGG

Special studies of unusual problems such as graphitization to assure long life and low maintenance.

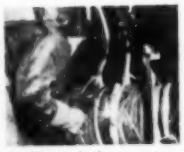
Metallurgical research by recognized specialists who have made major contributions in this field.



Exclusive Equipment for accurately analyzing stresses in piping and providing unique data for critical installations.

Complete facilities for the fabrication of steel products from simple forgings to specially cast bi-metallic devices.

Top welding performance in shops and in the field by welders accustomed to working under X-Ray checks.



Quality control, devised by metallurgical experts, embracing forming, heat treating and non-destructive testing.

Vessels
Exchangers
Condensers
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Forged and Welded Fittings
Radial Brick Chimneys

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The M. W. Kellogg Company, Inc. (A Subsidiary of Pullman, Inc.) — Offices in New York, Jersey City, Buffalo, Los Angeles, Tulsa, Houston, Toronto, London and Paris

lower viscosity, that the fuel oil usually burned, meaning greater consumption and readjustment of various valves and pressures.

Most used motor oils have varying degrees of gasoline dilution, which can lower the flash point of the reclaimed oil, where it may be dangerous to use, or necessary to exercise additional care in handling. The flash of a good lubricating oil may be as high as 350 to 400 F but after use, it may be as low as 80 to 90 F, and sometimes lower than those temperatures. Some oils, such as cutting, quenching, tempering, picked up from factories, are usually mixed with naphthas, and solvents, which will lower the flash point.

Where the reclaimed oil is a good grade, clean and free from light oil or gasoline dilution, the oil may have a too high flash point, causing some difficulty in starting.

Crude oils are sometimes burned without any refining. They vary from very light or thin in consistency, to heavy or viscous in nature. The lighter a crude oil, the more light material, such as gasoline can be obtained, and as the refiner realizes a greater profit from gasoline, he does not usually sell such a good crude for burning, when he can refine it and make more money. Only when there is an excess of these lighter crudes, is it sold as fuel oil. The heavy crudes do not contain so much potential gasoline, so it is this type that finds its way into the fuel oil markets.

When using the light crudes for combustion purposes, there are a number of precautions necessary that would not be with regular fuel oils.

As these light crude oils are considerably more volatile at normal temperatures, there is always a chance for fire and explosion, whereas with regular fuel oils, they must be heated before they vaporize enough to flash or ignite. Due to this condition, additional care must be exercised in the handling and storage of this material. The heavy crudes are not so volatile, and may be handled as ordinary fuel oils.

As the other types of fuel oils are the result of the refining processes, as described in Part No. 1, no further explanation will be needed. The various differences between these types of oils will be discussed as the various tests are explained.

Questions and Answers

Q & A—THE POWER ENGINEER'S FORUM—HERE'S HOW IT WORKS

YOUR QUESTION about some problem in operation, maintenance or design will be published, signed only with your initials.

Answers to your question from other readers will be sent you as soon as received, then published as space permits, so that all may have the information.

You, too, answer questions from other engineers in the same way. You get paid well for published answers and also get the credit for knowing them.

If other engineers help you solve your problem, you express your thanks, via the Q & A editor.

Simple, isn't it? And effective! Just ask engineers who have tried it!

Answer No. 452

THANKS TO ALL THOSE WHO HELPED ON HOW TO TEST A LADDER

MY QUESTION, How Do You Test a Ladder, in December, has brought in a lot of answers.

At our meeting of the Lodgepole Valley Municipal League in Sidney, Neb., we read the replies to the 20 members present and we thank all the writers of the replies for their efforts and interest in the subject.

The Lodgepole Municipal League is an organization for the exchange of ideas and help in any municipal problems, among power plants, water works and all other municipal departments.

Meetings are held each month in rotation among the seven towns belonging: Julesburg, Chappel, Lodgepole, Sidney, Kimball, Potter, in Nebraska; and Pine Bluffs in Wyoming.

A copy of the American Standard Safety Code for Wood Ladders was obtained by Vern Livingston and discussed at the meeting.

Pine Bluffs, Wyo. E. H. HARVEY

Answer No. 455

WILL ALCOHOL STOP BRINE FOAMING?

THIS QUESTION, in the March issue, asked for a method of eliminating foaming of brine in an ice cream plant.

We have had quite a bit of experience here in Dallas with this and can strongly recommend the use of DC Antifoam A Emulsion.

We will be glad to furnish M. C. J. with samples of DC Antifoam A Emulsion and also a new Emulsion known as XE-34, which some companies consider a little bit better for some applications.

Dallas, Texas M. H. LEAVENWORTH

Answer No. 456

CAN HE CONVERT 24-V D-C MOTOR TO RUN ON 110-V A-C?

IN THE March issue, C.D.F. asked if he could convert a 24-v d-c motor, connected as shown in the attached diagram, to operate on 110-v a-c, without rewinding, if that is possible. Here are just a few of the comments.

Each answer brings up the question of whether the motor is a true d-c motor with solid field cores, or if it has laminated cores. Also a number of questions are raised about those capacitors or condensers or whatever they are in that circuit. How is any current going to get through them to the motor? What kind of a gimmick is this anyway?

Comments from von Dunnenberg

IT IS IMPOSSIBLE to give a reply without more detailed information about the existing motor.

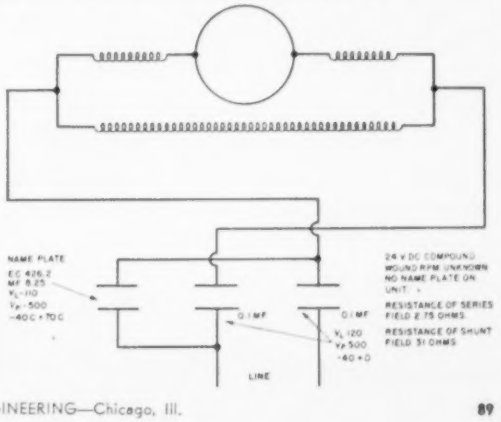


Fig. 1. Original diagram by C. D. F. showing connections of 24-v d-c motor he wants to convert to 110-v a-c operation

The d-c motor, if of an older type of manufacture would probably not be adapted to the change, particularly as it would probably have a magnetic field structure of solid construction. Just what relation the appended diagram may have to the existing motor can only be guessed at, although if it was supposedly used for d-c operation, further details are in order.

It is true we have today motors of the so-called Universal type, which can operate from either a-c or d-c; but their design and construction have to be carried out to meet this two-system operation. There was in the past, and many are still in operation, a motor developed for oil circuit breaker operation at either a-c or d-c and when operating on d-c an additional resistor was inserted in the supply circuit.

There is now a practice followed by a manufacturer in which machine tool motors requiring variable speed control are made d-c fed from a-c supply through a dry-type fan-cooled rectifier, which enables advantage to be taken of an a-c supply system and the superior speed control characteristics of the d-c motor.

The questioner does not indicate the d-c motor capacity or probable age of the equipment and the factor of age might make any attempt to change the winding open to question.

In view of the way the question is asked and its unknown, indefinite elements, the most direct approach of stepping down the a-c supply voltage through a 2-winding or auto-transformer and rectifying it to d-c for operating the motor seems the most practical way of solving the situation.

Brooklyn, N. Y. C. O. VON DANNENBERG

Comments from Valeatin

C.D.F.'s question about converting a 24-v d-c motor to run on 110-v a-c is a honey. What I would like to ask CDF is how that motor, assuming the diagram is correct, ever ran on direct current? Maybe the condensers were broken down but if they were in good shape, there is no way that direct current could ever get to that motor, nor enough a-c to run the motor either. Curious to see what this circuit was really like, I re-drew CDF's diagram as shown in Fig. 2. It is easier to follow in this form but it makes no more sense; direct current still would never get into the motor windings.

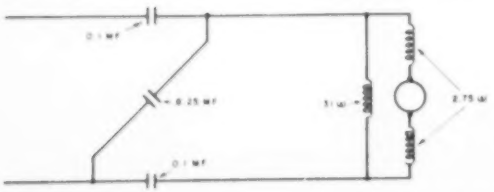


Fig. 2. By re-drawing Fig. 1 like this, says Valentin, we get a better idea of the circuit

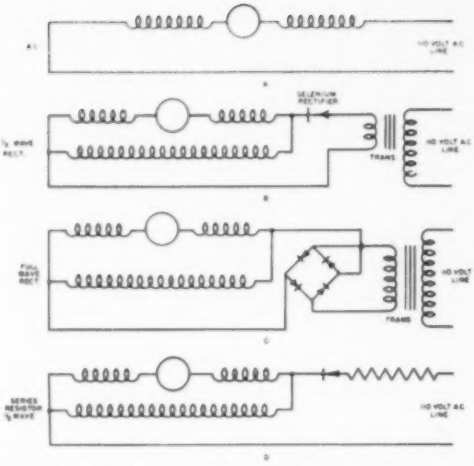
Fig. 3. Connections for the 240-v motor suggested by Dean Hvidston

A — Straight series connection

B—Use of selenium rectifier to convert a-c to d-c with ½-wave rectification

C—Use of rectifiers to give full wave rectification

D—Use of series resistor and ½-wave rectifier



So, I am wondering what sort of a gadget this is. I have a sneaking suspicion it is something that the army or signal corps cooked up. CDF gives no indication of the size of this motor, if it is a motor, or where he found it or what it might have been used for. The series condensers are very small, and even if this motor was connected across an ordinary 60 cycle a-c supply the current through it would be infinitesimal as can be seen from the following calculation of the capacitive reactance:

$$X = \frac{1}{2\pi f C}$$

Where f is the frequency in cycles per second and C is the capacity in *farads*.

Since the capacity of the condensers is given in microfarads, we have, for f 0.000001 x 0.1 = 0.0000001 farad.

$$X = \frac{1}{6.28 \times 60 \times 0.0000001}$$

$$\frac{1}{0.0000376} = 26{,}595 \text{ ohms}$$

Since the two 0.1 condensers are in series, the total capacitive reactance is 2 × 26,595 or 53,190 ohms. It is obvious that at 110 v very little current would pass through this motor.

Even if this were a conventional type of direct current motor, which obviously it is not, it still could not be converted to alternating current operation unless the field and armature structure was made of laminated iron. Direct-current machines are usually built with solid armature and field structures and if such machines are run on alternating current they would heat up rapidly due to the induced eddy currents in the iron. Modern Universal type motors, which are designed to run on either d-c or a-c, are built with laminated iron field structures.

It would be interesting to know what this gadget really is and what it might have been used for originally. With the information given by CDF there can be no logical answer to his question. The connection of the 8.25-mf condenser across the circuit also is very curious; it looks like a high-frequency by-pass condenser of some kind but the method of connection is unusual.

Ottawa, Illinois J. VALENTIN

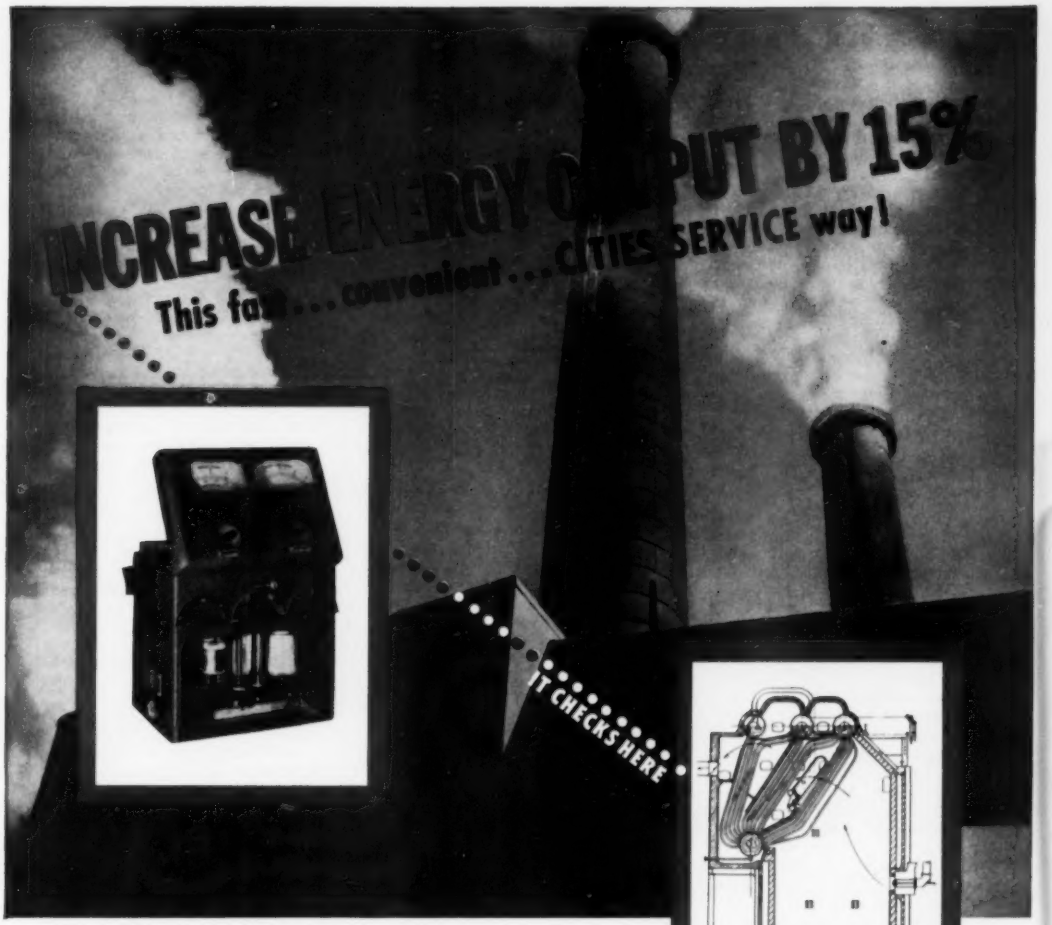
Comments from Hvidston

IT IS IMPOSSIBLE to operate this motor on a-c with the same characteristics as on d-c.

However, if C.D.F. can use a motor with series characteristics, he can disconnect the shunt field winding and apply 110 v a-c to the series field and armature in series, provided the magnetic circuit is of laminated construction.

The motor requires a higher a-c voltage than d-c because when operating on d-c, the voltage drop through the motor is dependent on resistance alone while on a-c it is dependent on impedance. While it is impossible to determine the exact a-c voltage from the limited data C.D.F. gives, most small 24-v motors will require more than 110 v for maximum output.

Incidentally, did this motor actually run on d-c, applying the line voltage through capacitors as shown in the diagrams? My guess is the capacitors are static suppressors and could not be wired in series with the motor as shown. Leave them off.



The Cities Service Industrial Heat Prover

This remarkable instrument is an exhaust gas analyzer, designed for use on industrial furnaces regardless of size or type. It is provided with three scales; one shows per cent of oxygen, another percentage of combustibles present and measured in the flue gas sample, and the third scale registers flue gas temperature.

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If a series motor will not do your work, you must use a rectifier to convert a-c to d-c. Selenium rectifiers would be the most economical. To determine the size and use, connect the motor to a 24-v d-c source and temporarily drive your load with it. Measure the current drawn at full load. Obtain a rectifier rated at this current at 24 v. These are available in any series or parallel combination to make your rating. A half-wave circuit will be satisfactory, although full wave will give slightly better commutation. Use a 110/24-v transformer, voltage drop in the rectifier is small.

A resistor could be used instead of a transformer but the starting torque would be decreased and the speed would vary more with the load. For variable speed use a rheostat.

Use ohms law to figure resistance:

$$\frac{\text{Line voltage minus motor voltage}}{\text{Full load motor current}} = \text{Series resistor in ohms}$$

Again I say, don't connect the capacitors in series; if you have radio interference, connect one across the armature.

Indianapolis, Ind. DEAN HVIDSTON

Conversion Not Practical, says Noble

C. D. F. will probably find it not advisable to convert his 24-v d-c motor to 110 a-c. Direct-current machines seldom make practical a-c motors because of the much higher magnetic losses in the field poles and other magnetic circuits. The a-c machines are laminated to reduce these losses, while d-c machines are designed for a steady voltage where such laminations are unnecessary.

To use this motor in alternating current circuits, the shunt field would have to be removed and the motor converted into a series machine. If the field were simply eliminated, the series field would probably be too weak to produce the required torque alone, so the fields at least would have to be rewound.

And, finally, the armature windings were designed for operation on 24 v d-c. What will happen when four times that voltage is thrown across them is not hard to imagine.

C. D. F's. best bet is probably to replace the 24-v motor with a new one designed for the service he intends to use it in. While conversions like this are occasionally practical, they generally result in inferior service and a conversion cost all out of line with the results.

Wilmington, N. C. DAVID H. NOBLE

Answer No. 457

HOW DETERMINE MOISTURE IN COAL SAMPLE?

COAL SAMPLES collected through their standard sampler crusher, said R.E.H. in the March issue, show consistently less moisture than samples of the same coal not run through the crusher. This affects the Btu as received by as much as 2 per cent.

Do others find this difference, he asked, and if so what do they do about it?

Mechanical Work of Crushing Drives Off Moisture, Says Poor

THERE ARE three main reasons why the Sturtevant-crushed coal samples show lower moisture than samples not so crushed:

(1) The mechanical work done in crushing the coal appears as heat, raising the temperature of the sample and driving off moisture.

(2) The crusher greatly increases the evaporative surface of the coal sample by reducing it to many very small pieces. (The exposed surface varies inversely with the average particle size.)

(3) The crusher agitates the small, warmed pieces of coal in the air, both inside the crusher and while discharging into the collecting can, providing extra opportunity for the moisture to evaporate.

It is difficult to obtain a truly representative moisture sample of coal, particularly if there is a wide range of particle size in the lot to be sampled. The recognized standard method of sampling is given in ASTM Standard D21-40, obtainable from the American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pennsylvania.

Less painstaking methods necessarily give less accurate results, but may prove adequate for some purposes. In any case, if the results of the analysis are to be used in commercial transactions between a coal customer and a coal vendor, it is important that both parties agree in advance on the sampling method to be used, and recognize that absolute accuracy cannot be obtained by even the best sampling method.

If the coal to be sampled is 1-in. slack or finer, and if a continuous stream of coal is available (such as a moving conveyor belt, or the downspout of an active coal bunker), a reasonably accurate sample can be obtained by taking a succession of small grab samples at intervals during the sampling period, making an effort to obtain a representative size consist in each grab sample. Each grab sample should be put immediately into an air-tight container (such as a mason jar) kept in a cool place, and the container should be tightly sealed at all times except when a sample is being put in it. The total sample should comprise at least half a dozen grab samples, and should amount to two to six quarts. If pieces larger than 1 in. are included, or if the lot to be sampled is stationary, the foregoing method should be modified to approach more closely to ASTM D21-40.

New York HUSTACE H. POOR

Must Stabilize Moisture, Says Justice

THE REASON for this discrepancy lies in failure to stabilize the moisture in the coal to room temperature before the sample is quartered and crushed. If the coal is crushed before it is air-dried in the laboratory, considerable loss of moisture may occur in the crusher and subsequent handling of the sample. As a matter of fact, the crusher may be considered as a rudimentary coal dryer because of the manner in which it agitates and exposes the coal to the air.

In order to stabilize the moisture, the gross sample should be carefully weighed as soon as possible after it is taken. It should then be exposed for drying in the laboratory air and stirred occasionally for at least three days until no further reduction in weight is apparent. The difference between these two weights gives the air-drying loss, and it can be calculated on a per pound basis. The coal sample can then be quartered and crushed without appreciable further evaporation of moisture to the laboratory air.

When the air-dried and crushed coal sample is heated in the oven, the remaining moisture is evaporated.

The total moisture in the coal sample is the sum of that evaporated in air-drying plus that evaporated in the oven.

To correct the moisture found in an air-dried sample to total moisture as received, the following formula may be employed:

$$\frac{100\% - \%\text{ of air-drying loss}}{100} \times (\%\text{ of moisture in air-dried sample}) + (\%\text{ of air-drying loss}) = (\text{total moisture as received})$$

If it is desired to speed the moisture stabilization prior to crushing, the sample can be dried in an oven maintained about 10 C (50 F) above laboratory room temperature, provided care in handling is exercised. Such drying should be continued until the loss in weight is not more than 0.1 per cent per hour.

WILLIAM C. JUSTICE

Silver Spring, Md.

COMING EVENTS

ICC—The Industrial Coal Conference will be held in Memorial Union Building, Purdue University, Lafayette, Indiana, May 9-10.

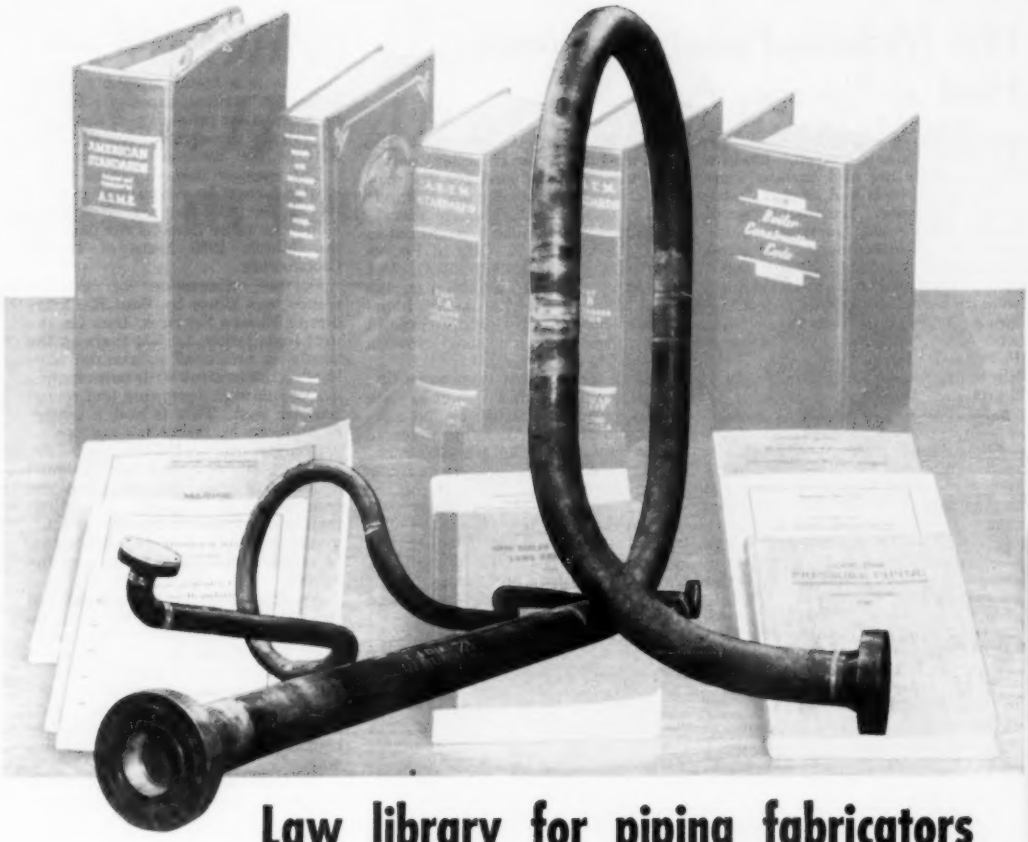
PEA—The Spring meeting of the Prime Movers Committee of the Pennsylvania Electric Association will be held at the George Washington Hotel, Winchester, Va., May 11-12.

ASME—Oil & Gas Power Division conference, Lord Baltimore Hotel, Baltimore, Md., June 12 to 16.

SMA—The 1950 annual meeting of the Stokers Manufacturers Association will be held at the LaSalle Hotel, Chicago, June 15.

ASME—The Semi Annual Meeting of The American Society of Mechanical Engineers will be held at the Hotel Statler, St. Louis, Mo., June 19-23.

ISA—The 1950 Instrument Conference and Exhibit of the Instrument Society of America, will be held in the Memorial Auditorium, Buffalo, New York from September 18-22.



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12th Midwest Power Conference Held at Chicago, April 5-7

LATEST DEVELOPMENTS in power plant design, modern steam generating and turbine generator units, fuels and smoke abatement, feedwater treatment, small power plant costs, electrical equipment, Diesel maintenance and latest developments in the gas turbine—all were covered in papers presented to more than 1500 leading power engineers from all parts of the country who attended the 12th Midwest Power Conference at the Hotel Sherman, Chicago, Ill., on April 5, 6 and 7.

Developments and Trends in Design and Equipment

Discussing recent improvements in central stations, G. A. Gaffert, partner, Sargent & Lundy, pointed out first the influence of fuel availability, price at mine or field and transportation costs on the design of power plants and the cost of producing power. Improvement has occurred in availability and overall efficiency of the steam cycle. Proper design of furnaces and other equipment has led to lower maintenance, less forced outage and superior performance. With steam temperatures from 950 F to 1050 F, close regulation of the steam temperature by a number of different methods, and as close as 10 F, can be attained. Increased cost of fuel makes it desirable to design for 87 to 90 per cent boiler efficiency.

A recent development is pressurizing the furnace and eliminating induced draft fans, thus reducing fan power about 25 per cent and increasing boiler efficiency about 0.5 per cent. Mr. Gaffert discussed the cyclone-furnace-fired boiler, pointing out that its advantages are partial crushing only of coal, elimination of dust collectors and moderate furnace cleaning (also brought out in the article by F. X. Gilg in POWER GENERATION, April 1950 issue). Use of mechanical air evacuation equipment eliminates one use of high-temperature steam, while use of compressed air for soot blowing eliminates another.

Future trends will raise operating temperature: a few stations are being designed for 1050 F, and considerable attention is being given to the reheat cycle, 1500 psi 1000 F reheat to 1000 F. Comparative analyses by the speaker indicate that the reheat cycle pays a 20 to 25 per cent return on the added investment over the non-reheat cycle. Further improvements are keyed to metallurgy.

Use of outdoor and semi-outdoor equipment is increasing. Increased personnel costs are leading to greater centralization of control for the entire plant and by these means the newer stations are reducing manpower costs.

Discussing basic factors of steam power station design, B. C. Mallory of Stone & Webster Engineering Corp. reviewed first the various factors determining choice of initial steam pressure and temperature and whether or not reheat is desirable. Another problem, said Mr. Mallory, is "Should equipment be arranged as a skyscraper or more nearly like a ranch house?" Design of foundations, climate, use of outdoor equipment and similar factors influence this.

There is a trend toward a single boiler per turbine, especially for reheat units, for reliability of the modern steam generator nearly equals that of the turbine generator.

The speaker then discussed many of the factors in centralized control for power stations, some of them along the same lines as his paper in the March 1950 issue of POWER GENERATION.

Further discussion of modern trends was given by Paul E. Gourdon of Ebasco Services, Inc. On the unit installation, he felt that, on the whole, it produced substantial savings in investment with corresponding decrease in operating and maintenance cost. This is still a matter of opinion.

Commenting on the outdoor plant, of which his company has designed a large number, he reviewed the conditions of climate, reliability, maintenance, weatherproofing of individual units and so on, elimination of building costs that have been involved.

An important point brought out by Mr. Gourdon is that only in recent years has the cooling tower been established as an important means for cooling condenser circulating water in central stations. Today the location of many steam plants is resolved economically by cooling the circulating water in this way.

Turbines are being set on lower pedestals, especially in outdoor plants, (see Greens Bayou Station, April 1950 issue) with the auxiliaries alongside them.

J. R. Carlson of Westinghouse Electric Corp. reviewed the progress to higher steam conditions that has been closely related to metallurgical developments and showed these developments in the design and application of 3600-rpm turbine generators.

All Engineers Dinner, 12th Midwest Power Conference in Grand Ballroom of Palmer House, April 6, 1950

Small Plant Costs

Charles Schott, chief engineer, Frank Fehr Brewing Co., explained the factors leading his company to study the cost of its maintenance work, especially piping maintenance. The author's company came to the conclusion that a welded pipe line is neater, stronger, requires less maintenance and less delay in placing a new pipe system in service and that the initial cost of welding joints is cheaper than other forms of construction on lines 4 in. or larger.

Fuels and Boilers

Coal's Place in the Sun was treated by Bertrand A. Landry of Battelle Memorial Institute, who pointed out the relation between coal's present position, the increasing use of fuel oils and natural gas, the conversion of locomotives to Diesel operation, expansion of natural gas pipe lines and other factors.

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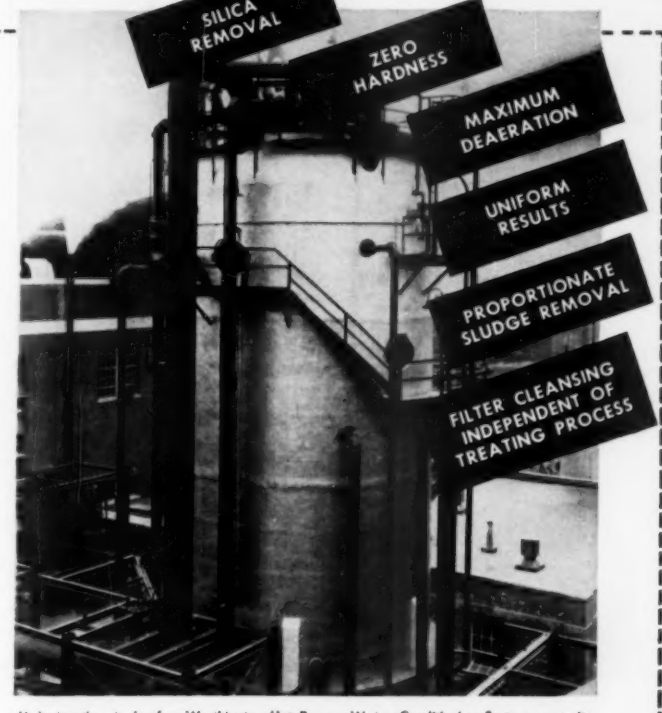
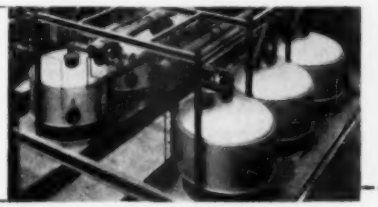


Main treating tank of a Worthington Hot Process Water Conditioning System, capacity 900,000 lb. of treated water per hour



Six pressure filters 11 feet in diameter used for final clarification in this Worthington Hot Process Water Conditioning System

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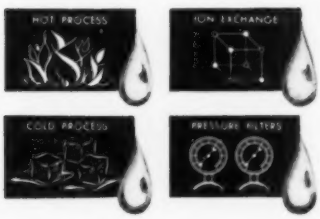

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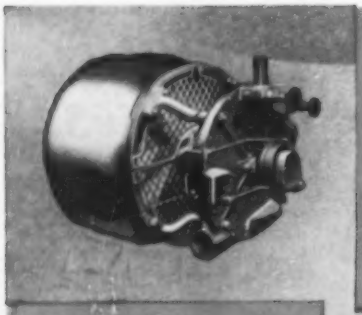

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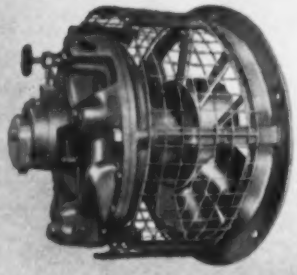

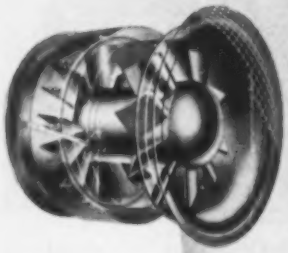

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His conclusion was that coal is most apt to profit from an increasing total demand for fuel energy.

Boyd Guthrie, Chief of the Oil Shale Demonstration Plant at Rifle, Colorado, reviewed the factors in producing industrial fuels from oil shale.

A symposium included discussion of magnetic iron oxide scale in a 420-psi boiler by John H. Moore of Otter Tail Power Co.; localized formation of magnetic iron oxide in power boilers by H. M. Rivers and W. M. Sonnett; prevention of black iron oxide deposits following chemical cleaning by P. H. Cardwell of Dowell, Inc.; and experimental studies of iron oxide deposits in boilers by Clarence Jacklin and Harris Thompson.

In surface condensing power plants, said J. D. Yoder of The Permutit Co., loss of power can be avoided by using demineralized water as makeup and still maintain substantially the same solids within the boiler as when using evaporated makeup.

The dual-circulation boiler, it was pointed out by R. A. Lorenzini, of Foster Wheeler Corp., grew out of the necessity of utilizing waters in high-pressure boilers that heretofore were considered undesirable when the makeup was high. Such a boiler is installed at the Whiting Refinery of Standard Oil Co. (Indiana) (see POWER GENERATION, April, May and August 1948).

Power and Heat Distribution

Reserves to be provided in the modern power system were treated by Howard P. Seelye, chief engineer of The Detroit Edison Co., who said there is no one best answer. He discussed the function of reserves, the use of reserves for maintenance, for unforeseen load, for emergencies, reserves in generating facilities and total reserves, pointing out that very exact figures on reserves are usually not warranted, since they serve mostly as background for decision in which good judgment is most important.

An unusual and interesting way in which a private utility and a rural electrification district cooperative have worked together successfully to solve their problems was given by John M. Drabelle and E. Henderson of Iowa Electric Light and Power Co. The whole scheme eliminates a vast duplication of facilities of every character and relieves the REA distribution cooperatives of creating a large staff of employees for operating them.

In a symposium on atmospheric pollution, Frank A. Chambers, Chief Smoke Inspector of the City of Chicago, first outlined the factors in smoke abatement administration. The technical aspects of air pollution abatement were reviewed by A. D. Singh of the Singh Co. Field and laboratory methods of air pollution

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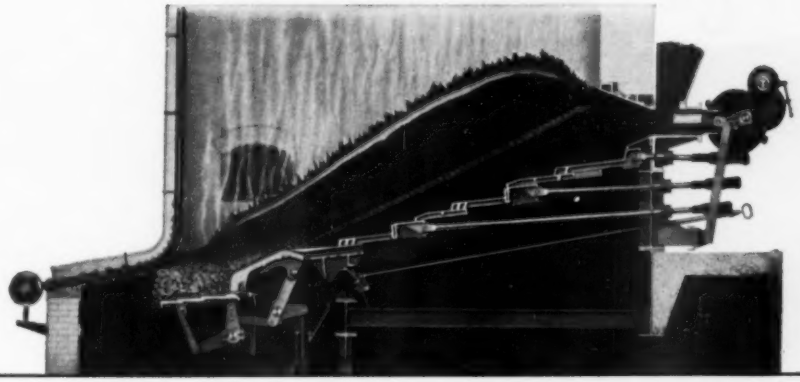

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study were reviewed in a paper by Paul L. Magill and R. W. Benoliel, presented by Dr. Munger.

H. B. Lammers of the Coal Producers Committee for Smoke Abatement said the engineering factors in smoke abatement are: assembly of facts, not hearsay; more attention to engineering, equipment and education; economic factors, who will pay for the program; greater emphasis on the administrator rather than on legislation; acceptable standards; difference between nuisances only and health factors; public support; and combined help of experts in all fields.

Electronics in the Power Plant

Use of electronic instruments by the power industry is increasing. However, the problems involved in designing instruments for this field are quite special and the factors involved in designing and using them were effectively explained by George E. Foster of Metrotype Corp.

Charles H. Smoot, Jr., of Republic Flow Meters Co., explained an electronic device for transmitting information between mechanisms to control boilers—fundamentally an electronic master controller based on the alternating-current Wheatstone bridge. It produces a mechanical motion output which causes a controlled device to operate as desired. The entire boiler control is a combination of this electronic information transmission system with various types of positioners and pneumatically-operated regulators.

Gas Turbine Progress

In a session on the progress of the gas turbine, the principal item of interest was the progress report upon the coal burning gas turbine locomotive by J. I. Yellott of the Locomotive Development Committee. Following several years of experimental work with various components, they have now been assembled in the form of a coal-burning Houdry gas turbine plant at Dunkirk, N. Y. This is not intended to produce power and has no generator, but is intended to study the operation of a full-scale gas turbine plant burning coal. Full details will be given in a subsequent issue.

T. J. Putz of Westinghouse Electric Corp., described a 4000-hp gas turbine locomotive for passenger service; its main power supply will be from two 2000-hp, simple, open-cycle gas turbine generator sets, with an electrical power transmission.

The contact converter or mechanical rectifier for transforming alternating current to direct current by mechanical means, was described by Otto Jensen of I-T-E Circuit Breaker Co. At the present time it is limited to the 50-400-v d-c range. Mr. Jensen described installations at the Buffalo Electro-Chemical Co., and at the Hydrogen Plant of Canadian Resins & Chemicals Ltd.

At the All Engineers Dinner of the Conference, Robert E. Wilson, Chairman of the Board, Standard Oil Company (Indiana) was toastmaster and Philip D. Reed, Chairman of the Board, General Electric Co. and President, International Chamber of Commerce, was the guest speaker. After reviewing the achievements of American private industry and pointing out that one of the principal factors in its success is the availability of the tremendous electric power industry of the United States, Mr. Reed discussed the role of the business man as internationalist, business statesman and educator.

Another angle on this subject was given by K. W. Haagensen, of Allis-Chalmers Mfg. Co., when he said that we must throw off the negative approach and instead sell our intangible American way of life from a positive and constructive point of view.

J. H. Jewell of Westinghouse Electric Corp. pointed out that from now on electric living, invading all fields of American life, will require sales power to sell electric power to make this living possible.

R. A. Budenholzer, Professor of Mechanical Engineering at Illinois Institute of Technology, is director of the Midwest Power Conference and Edwin R. Whitehead, also of IIT, is Conference Secretary.

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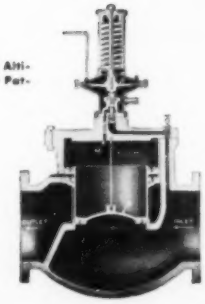

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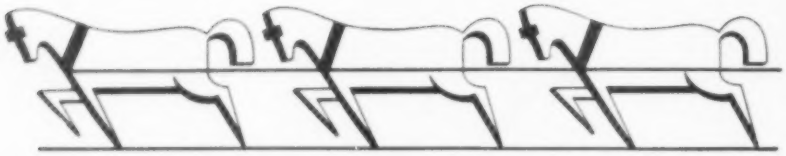

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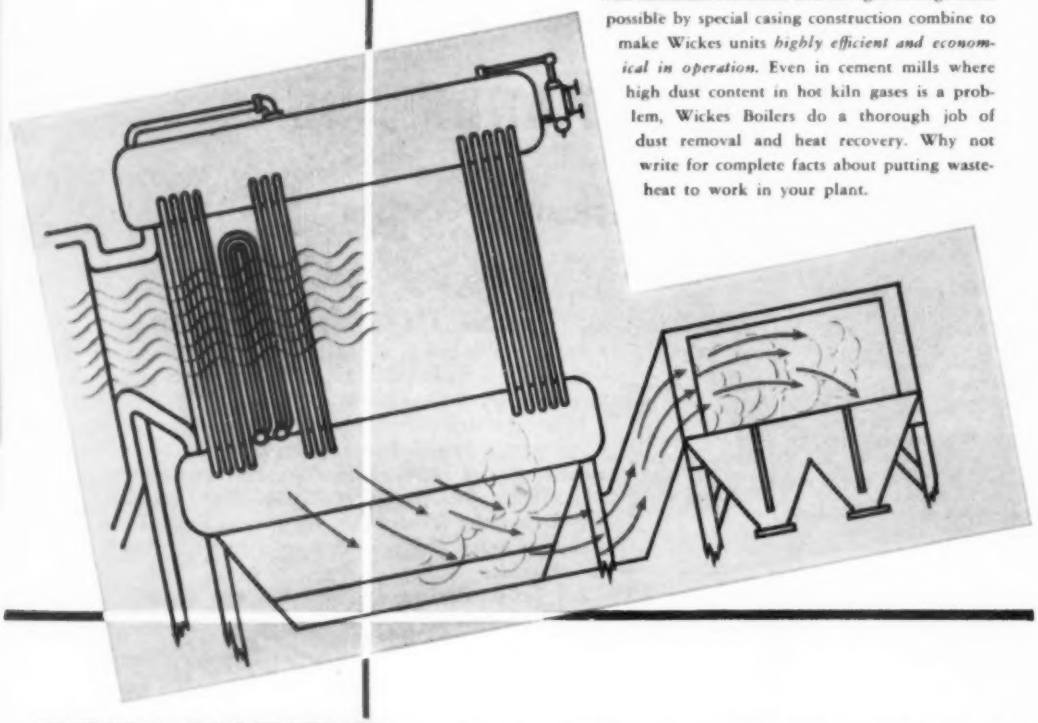

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Progress Report on 2nd Experiment in UNDERGROUND COAL GASIFICATION

As described in our September 1947 issue, the U. S. Bureau of Mines and the Alabama Power Co. began in that year to experiment with underground gasification of coal at Gorgas, Ala. . . . They determined coal could be burned in this way, producing gas of varying quality . . . Second experiment began in March, 1949 . . . This article tells you what has been learned so far and indicates some of the problems still remaining

By **MILTON H. FIES,***
Manager of Coal Operations,
Alabama Power Co.

IN UNDERTAKING this project, the interest of the U. S. Bureau of Mines and the Alabama Power Co. was initially to determine whether coal could be burned in a dependable manner in the earth. The power company recognized the need for an economical source of fuel for boilers and the great potentialities of the gas turbine. There was an awareness that low-cost oxygen would become available in time, with subsequent production of higher quality gas and a vast contribution to the science of metallurgy and chemistry.

Products of Underground Gasification

The gas produced by burning coal underground consists of a mixture of nitrogen, carbon dioxide, carbon monoxide, hydrogen, methane and some higher hydrocarbons.

Heat is available from these gases in two forms—first, as *sensible* heat when they are cooled from a high temperature to a lower temperature; and second, as heat of *combustion* when the gases are burned with additional oxygen.

For generation of steam, with which to operate a steam turbine-electric generator at the site of the underground gasification, both sensible heat and heat of combustion could be used. The boiler plant should be close to the exit of the underground gasification operation, and the gases taken to it at as high a temperature as possible.

In utilizing the gas in a gas turbine, the turbine can be located at the gas outlet, the sensible heat extracted through suitable heat exchange equipment, and the heat of combustion obtained in the combustion chamber of the turbine. Over-all efficiency of such a gas turbine installation may be 25 per cent to 50 per cent greater than is now obtainable from present mining methods followed by coal utilization in a steam power plant.

To produce a synthesis gas for making oil and gasoline from underground gasification, it probably will be necessary to use oxygen instead of air underground. It is contemplated that resulting gases would be synthesized by the Fischer-Tropsch Process to yield gasoline and Diesel oil.

There are a number of other possible uses for the products from underground gasification; for example, in the production of chemicals or higher Btu gases, but no extended analysis has yet been made of these potentialities.

Results from Preliminary Experiment

In the preliminary experiment† in underground gasification at Gorgas, the following results were obtained:

1. There was no difficulty in maintaining combustion of coal underground.
2. Coal in place was gasified completely; only ash and clinker remained in the combustion zone.
3. Roof rock became plastic, expanded, and settled on the mine floor directly behind the reacting coke face. Settlement of the rock roof forced the air and gas to pass through the narrow openings along the coke-rock interface.
4. A gas of varying quality was produced by the several methods employed.

Conditions of the Second Experiment

Accordingly, the second experiment was undertaken, beginning on March 18, 1949, and it has progressed. The Alabama Power Co. made available some 100 acres of coal land and technical assistance, both without cost to the Government. The installations were made and the conduct of the experiment has been carried on by the power company at bare cost. The Bureau of Mines has planned, supervised, and directed the work and financed the services and facilities used in the preparation and operation of the project. It has been estimated that the Government alone will have expended, through June 30, 1950, some $750,000 in the experiment.

This second experiment is much more extensive and flexible than the first. If progress continues, varied approaches to the process will be applied, to which reference will later be made. It is likely that, with additional appropriations, the work at Gorgas may continue for another two or three years. The author presented the following comments on it before the New York Society of Security Analysts in November, 1949.

The coal bed is 42 in. thick and relatively level. It lies under an average overburden of 150 ft. At the

* Consulting Mining Engineer, The Southern Co.; Consulting Mining Engineer, U.S. Bureau of Mines.

Fig. 1. First products of combustion emitted directly after coal was fired in second underground coal gasification experiment at Gorgas, Ala.

† Described in an article, How Coal is Burned in the Mine to Produce Power and Synthesis Gas, by Chester R. Earle, *Power Plant Engineering*, September, 1947.

Fig. 2. How the fire was started in the coal underground by dropping an incendiary bomb into it through one of the bore holes

northern end of the project a vertical face was made on the coal outcrop and an entry and air course were driven south for a distance of 1240 ft. The entry and the air course are each 10 ft wide and are separated by a coal pillar 10 ft thick. Every 300 ft they are interconnected by means of cross cuts driven through the coal pillar.

During the operation of the underground gasification project, approximately 3000 tons of coal have been burned in place, as of November, 1949. The ribs of the original 10 ft entry have been burned back so that the coal has now been burned from an area 70 to 75 ft wide and 300 ft long. Several test holes have been put down in the area where the coal has been burned out and show that in these regions there are few or no void spaces in the rock above the coal bed. Roof action away from the original entry has apparently been favorable.

The project to date has shown that the major difficulty to be surmounted is the by-passing of air through non-reactive material and the subsequent combustion of the product gases before they can be removed from the system. A measure of success in controlling or preventing this by-passing of air has been achieved through the introduction of fluidized sand into the void spaces appearing underground. The indications are that roof action in this area tends to be favorable to the process of underground gasification.

The introduction of *fluidized sand* above the rock falls, thus diverting and directing the air flow toward the burning face, *is a long step forward in underground gasification of coal.* Many engineers have been skeptical because of their doubt that control can be exercised. In this experiment it has produced results. In the burning of coal beds at not too great a depth, it probably can be the means of overcoming the crux of underground gasification, which is control of the roof or strata directly over the coal.

If a means of gasifying coal can be devised independent of roof action, control can be simplified.

Accomplishments of the Experiment

The experiment has been going continuously since March 1949. Reviewing the accomplishments thus far, there must be some degree of conjecture:

1. Some 3000 tons of coal from the initial 300-ft passageway have been consumed, and no limit as to the quantity of coal which can be consumed from a passageway has as yet been reached. No difficulty has been encountered in maintaining combustion, and after all, that is the first step.

Gas quality has not been stressed in these initial experiments. The fundamental purpose is to make a gas with *constancy* and *continuity;* then exercise control. If a producer gas results, then a further step will be to produce a higher quality gas through the use of oxygen and steam with the assistance of fluid catalyzers.

2. When dealing with gases of high temperatures, outlets and refractories are important. To date, the bore holes which have been installed at this project have functioned adequately as hot gas outlets and air inlets. Both the unlined bore holes, and those filled with refractory linings have served adequately as hot gas outlets from the system. At the completion of the experiment it may be well to study the comparative effects on each.

3. It is not yet possible to determine the operational characteristics for several variables such as the length of passage required, the optimum rate of flow, and the pressure drop encountered. To date only a 300-ft length of passage has been used in the operation of the project. Some eminent gas engineers think this passage is not sufficiently long —others think it is too long. It is expected to set up in the near future a system whereby a shorter length passage will be utilized in an effort to obtain a short and very hot reaction zone. The best operating conditions have so far been realized when the maximum rate of flow ob-

(Continued on page 122)

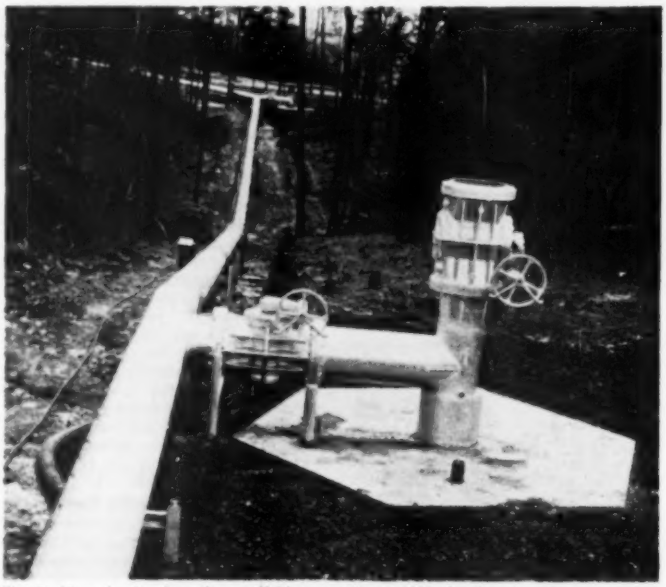
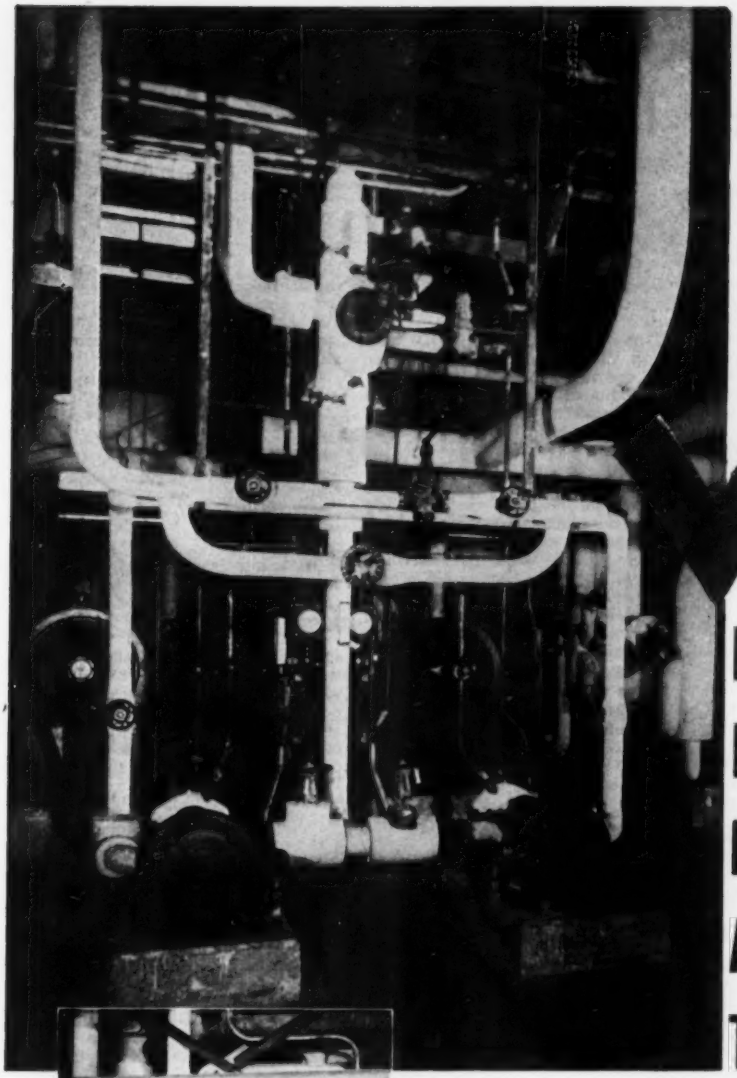
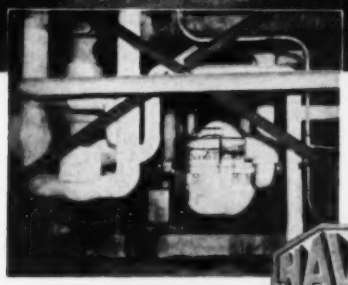


Fig. 3. View showing how the manifold connecting a 7200-cfm, 30 psi compressor passes underground through bore holes





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The 62,000-hp Vertical Impulse Water Turbines for Bridge River

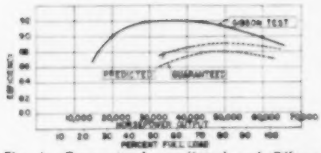


Fig. 1. Guaranteed, predicted and Gibson test performance of Bridge River 62,000-hp vertical impulse turbine

INITIAL CONCEPTION of Canada's Bridge River Power Project at Shalalth in British Columbia dates back to 1910, but nothing came of the venture then, because the site was 130 miles northeast of Vancouver and the power demand was then insufficient to justify the expense.

In 1913, study of the Bridge River run-off was begun; and since that time engineers of the Dominion Water and Power Bureau, together with British Columbia Electric Railway engineers, have compiled authentic hydrometric records on which the company has been able to plan complete utilization of the water supply.

These studies revealed a power potential of 600,000 hp and the long-range planning of B. C. Electric contemplates two tunnels through Mission Mountain and several penstocks feeding a group of 62,000-hp turbines.

General Design of Bridge River Project

Flow of the Bridge River, in common with other streams in British Columbia, is subject to wide variation from the snow-melting high water period in the summer to the low-water winter months when demand for electricity is at its peak. Accordingly, it was necessary to construct the Lajoie storage dam, Fig. 2, with a present capacity of 170,000 acre ft and an ultimate capacity of 570,000 acre ft, 40 miles upstream from the diversion dam which directs the water through a 2½ mile long tunnel, 14 ft 3 in. in diameter, carved out of the solid rock of Mission Mountain.

Three individual 75 in. OD penstocks, 2100 ft long, carry the water from the tunnel mouth down to the power house, Fig. 2, where three 62,000-hp, 50,000-kva, 3-phase, 60-cycle, 13,800-v turbine-generator units, Figs. 3 and 4, are now in operation.

The impulse type water turbines installed in this plant are the result of careful design and much preliminary test work by the Pelton Water Wheel Co. This work was described in detail by W. F. Boyle, vice president and general manager and I. M. White, manager of engineering, of the Pelton Water Wheel Co., in a paper before the 1949 Annual ASME Meeting.

Design of Vertical Impulse Turbine

In 1946, a contract was awarded to Pelton—VEW for a four-nozzle vertical impulse turbine, for the Bridge River plant, to meet these design conditions:

Turbine rating	62,000 hp, 1118 ft eff. head, 300 rpm
Guaranteed efficiency	88%
Predicted efficiency	89%
Present gross head	1226 ft
Max. gross head (future)	1360 ft
Max. eff. head	1171 ft
Max. surge head	1465 ft
Hydrostatic test pressure	935 psi, 2160 ft head

Early in Pelton's studies, it became clear that a six-nozzle turbine had many points in its favor over the four-nozzle turbine that Pelton had contracted to build. Consequently, Pelton undertook an extensive testing program to examine all facets of both designs.

Testing and Model Studies

Briefly, the objectives of the testing program were: First, casing studies to determine that fluid path which provided minimum losses between turbine inlet and individual jets; second, housing studies to establish that contour which would most effectively clear the water from the upper runner discharge; and third, extensive efficiency tests to insure that the last tenth of a per cent was being extracted from the power fluid.

A plastic model of the 54-in spherical valve, a 1/5 scale model of the six-nozzle turbine, 25 different versions of housing shapes and proportions and baffle arrangements, a 3/10 size model, various runner and bucket designs were constructed and carefully tested. From these tests, the design as shown in the illustrations was developed, yielding the efficiencies shown in Fig. 1.

A new type of spherical valve, Figs. 3 and 5, was developed for the Bridge River turbines, with the seats on the plug and in the body located off center with repect to the flow passageway in such a manner that rotation alone brings the plug seat into register with the body seat. In the open position, the valve produces a cylindrical passageway equal to the diameter of the inlet. On shop

Fig. 2. Flow diagram of the Bridge River Hydro Development showing relation of dams, penstocks and power house

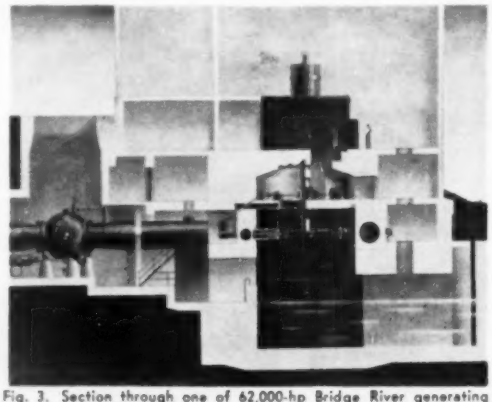
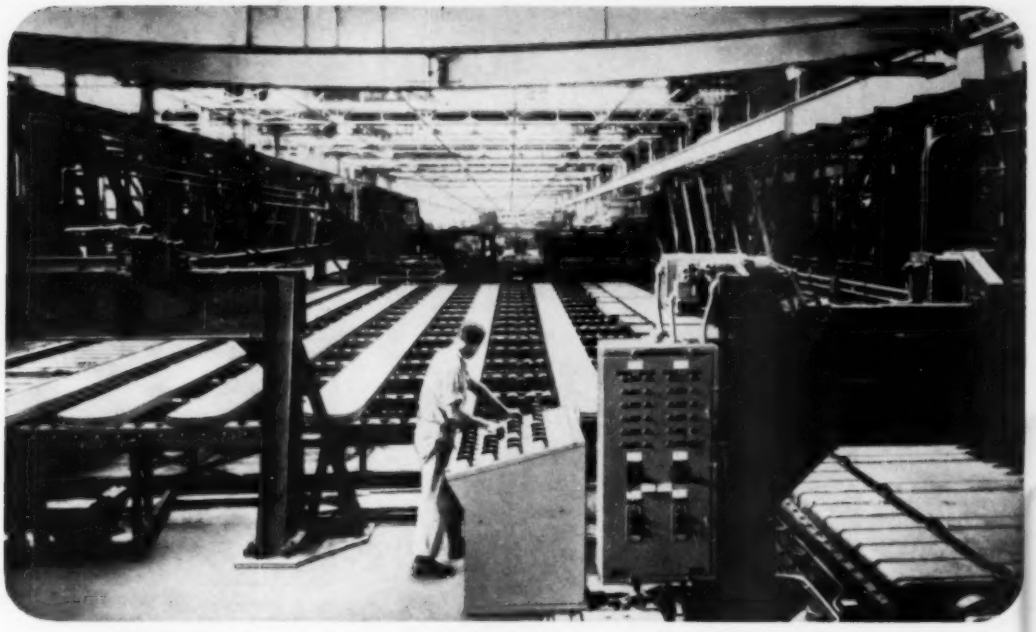
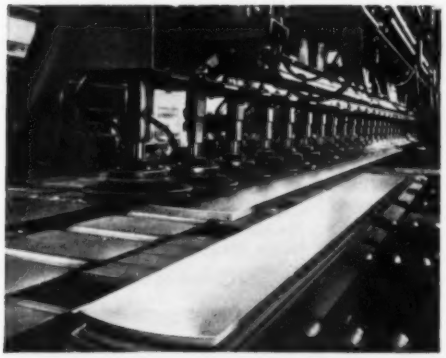


Fig. 3. Section through one of 62,000-hp Bridge River generating units showing 54-in spherical inlet valve, turbine setting, controls



TO BUILD OR NOT TO BUILD



The smaller illustration is of the vacuum cup handling equipment operating in conjunction with the 2-Hi Cold Rolling Mill. Because of the massive size and weight of individual brass bars, all handling is mechanical.

This Mill, designed and constructed by Stone & Webster Engineering Corporation, is capable of producing the heaviest non-welded coils of strip brass, and includes the largest cold breaking-down mill in America.

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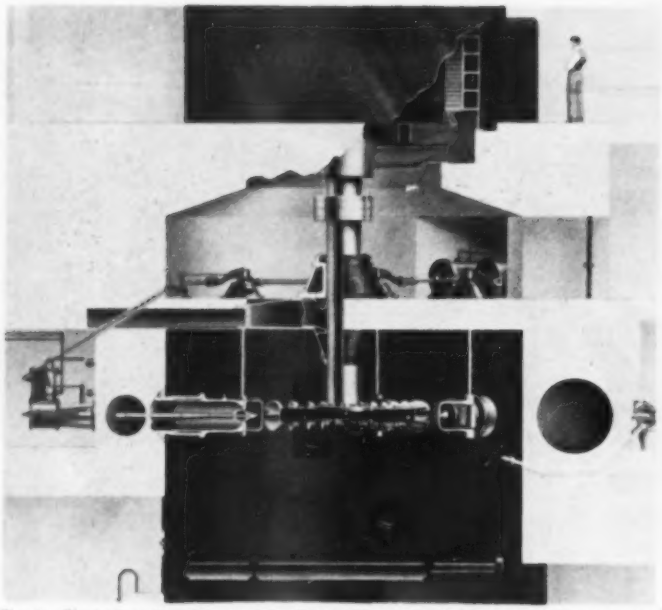

Fig. 4. Close-up section through one of Bridge River's 62,000-hp vertical impulse water turbine generators

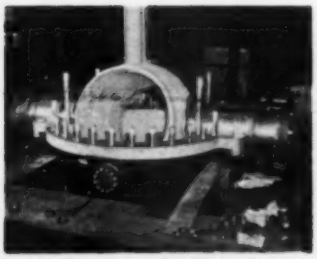

Fig. 5. Shop view of half of the 54-in spherical valve body, with plug in place

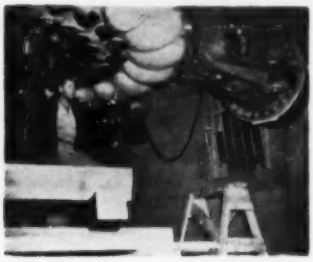

Fig. 6. Underside view of Bridge River turbine wheel, nozzle assembly and wheel pit erosion protector

tests on the full-size valve, under a head of 935 psi, there was a leakage through the seat of the order of 10 drops per minute, which is exceptional for a 54 in. valve under high pressure.

Turbine and Control Construction

All dimensions of the wetted surfaces have been stepped up from the model by applying a factor of five. A mechanical structure has been built with inside dimensions conforming to the hydraulic fluid path and of sufficient strength to withstand a maximum surge of 1465 ft. The portion of the turbine wheel pit that must take the full impact of the deflected jets at times of load rejection have been reinforced to handle the load.

The combination turbine-generator unit is a short-coupled, three-bearing arrangement with two generator bearings and one turbine bearing. The top generator bearing is of the conventional thrust type and supports the total load of all of the rotating parts. In the general power house design, basic floor levels have been nicely related to the several operating levels of the turbine as in Fig. 3.

Speed and load control is accomplished by the very flexible governing system illustrated in Fig. 7. The primary governor is a Woodward cabinet actuator located on the generator floor, which directs the flow of oil to or from the servomotors in the turbine pit to control the position of the six interconnected deflectors. Normally, each deflector operates in a position just outside of its jet. In the event of load rejection, the deflectors rapidly enter the jets by control from the actuator, so that the entire hydraulic force is removed from the wheel and deflected into the wheel pit. The timing of the deflector, in the case of load rejection, is set for approximately two seconds so as to hold the speed rise following load rejection to a low value.

An interconnection is provided between the deflectors and the needles through a jet controller, so that movement of the deflector brings about a gradual closing of the individual needles.

Maintenance

The vertical impulse turbine is fundamentally amenable to maintenance because the main bearing, de-

(Continued on page 120)

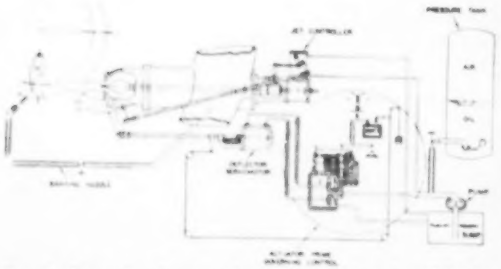

Fig. 7. Schematic diagram of governing system for 62,000-hp vertical impulse turbine

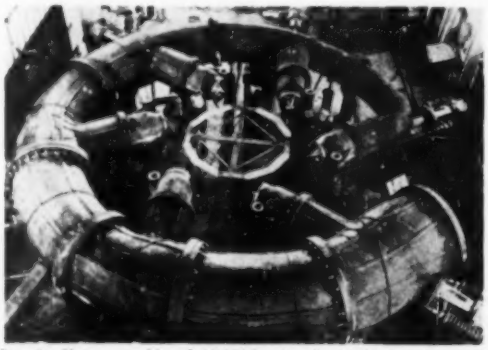

Fig. 8. Shop assembly of 62,000-hp impulse turbine casing and needle nozzles. Position of runner indicated in center

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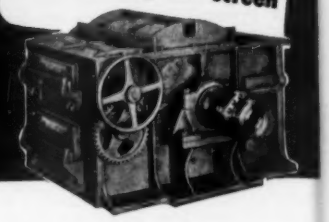

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. . . this crusher is giving a performance that is typically American—*typical* because American Crushers are engineered to "take it," and are *tested in actual use*. They slash power and labor costs too, and cut out-of-service time to a minimum. *Here are a few construction "whys" behind American records—*

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Let an American representative analyze your crushing problem. Also, we'll be happy to send you our bulletin "Crushing Coal at Less than One Cent Per Ton."

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New Absorption Refrigeration Unit Uses Water Vapor

Growth of air conditioning in industry has led to need for a heat-operated refrigerating machine for all temperature ranges and for capacities of 100 to 350 tons . . . New unit, designed to meet this need, uses lithium bromide salt solution, steam at pressures from 10 to 200 psi, consumes 19 lb steam per ton per hr . . . How the machine works, how it performs, applications, costs of operation

By A. A. BERESTNEFF
Carrier Corp.

DURING THE last few decades there has been a growing realization of a great need for an economical, heat-operated refrigerating machine for all temperature ranges. The tremendous growth of air conditioning has particularly emphasized this need in the field of high-temperature refrigeration applications requiring chilled water service.

At present, three more or less extensively used kinds of heat operated refrigerating machines normally use steam as a heating medium: 1. Steam-driven compression machine (mostly turbine-driven centrifugals); 2. Steam-jet machine; and 3. Absorption machine.

The first two are handicapped either by high first cost or high operating cost, particularly at medium and low steam pressures. The old absorption machine using ammonia-water as a working medium suffers similar handicaps. Furthermore, the hazardous nature of ammonia prohibits use of this machine for air conditioning.

In the last 15 years, two new absorption machines have been developed in an effort to overcome the handicaps of the ammonia system, one produced by Servel, Inc. and the other by Williams Oil-O-Matic Co.

The Servel unit is available in a capacity of 3 and 5 tons. It is operated by gas through the medium of steam, which is generated in a special boiler provided as an integral part of the unit.

The Williams Oil-O-Matic unit is made in capacities between 12 and 35 tons. The machine is operated by steam generated outside of the unit.

These two units represent a considerable improvement in design of absorption machines and fit well into high-temperature application. However, they cover only a comparatively small range of low capacities. As a result, until very recently there was not any steam-operated machine suitable for the medium and large capacity range.

In recognition of this situation, a development was started in 1941 by Carrier Corp. with the purpose of producing a fair-sized absorption machine for chilled water service, economical in first and operating cost. Culminating this work, the new machine was publicly announced and released as a standard product in May 1949. Its construction, operation and performance were described by the author in a paper before the 1949 Annual ASME meeting.

Each one or a combination of the following conditions, he pointed out, makes this machine especially attractive:

(1) Localities with low cost fuel

Table I. Steam consumption in pounds per ton per hr for various types of steam-operated refrigeration machines. Condensing water entering at 85 F and chilled water leaving at 45 F taken as bases for comparison

Steam Pressure, psig	10	100	200
New Absorption Machine	19	19	19
Turbine Driven Centrifugal*	30	22	18
Steam Jet**	50-60	30-35	20-25

* Vacuum 26-28". Size about 150-200 hp
** Condensing water 6-8 gpm per ton

Table II. Space and weight data for several sizes of water-vapor refrigeration machines

Nominal capacity, tons		115	150	200	270	350
Over-all dimensions, in	length	140	175	227	208	252
	width	58	59	60	71	72
	height	103	109	109	120	126
Net weight, lb. approx.*		8200	10600	14200	18900	24800
Operating weight, lb. approx.*		9820	12750	17060	22900	29900

* For high-pressure steam. For low pressure steam, the values are about 8 per cent higher.

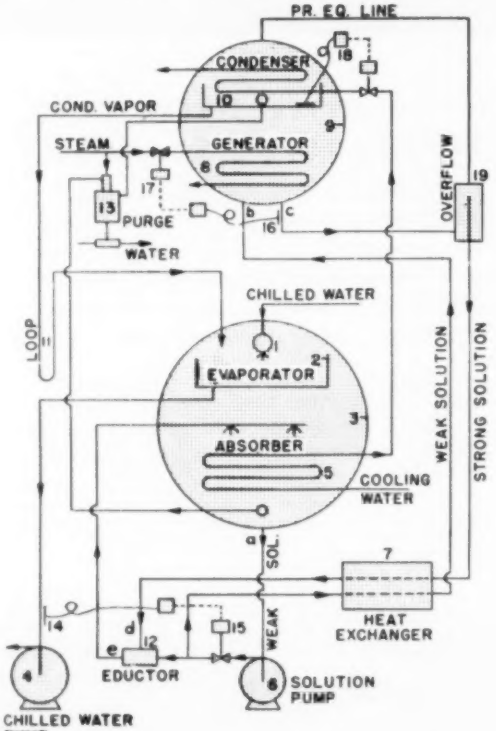

Fig. 1. Schematic diagram showing operation of new lithium-bromide water vapor absorption refrigeration machine

A NEW REFRIGERATION CONDENSERS BOOKLET BY Vogt

Write FOR BULLETIN RC-1

Here's pertinent, up-to-the-minute information on our complete line of refrigeration condensers . . . a 24 page booklet showing types and sizes designed to deliver low temperature liquid with the lowest condensing pressure.

Vogt Refrigeration Condensers are fabricated from top quality plates, tubes, pipes, forgings, and castings by skilled workmen in modernly equipped shops. Units are designed, tested and stamped to A.S.M.E. Code requirements.

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The New

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Gives you the

POWER

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FASTER

You won't believe any tube cleaner can pack such tremendous power, until you try the new ROTOJET. It removes scale so much faster that it usually pays for itself in one cleaning. Models available for practically any size straight and curved tubes. Send for ROTOJET Bulletin.

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ROTOJET Motor has only two moving parts, a shaft and a paddle. Positive contact between paddle and Rotocentric (egg-shape) bore cylinder prevents stalling at low speeds. No leakage. Delivers maximum power for air used.

S-530 ROTOJET Air-driven Motor with swing-frame head for 3¼"–3-13/16" I.D. straight tubes

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such as in areas with natural gas.

(2) Localities with high electric rates.

(3) Places where low pressure steam, especially waste steam, is available.

(4) Cities where steam or gas utilities want to build up summer loads.

(5) Individual buildings with heating boilers remaining idle during the cooling seasons.

(6) Other considerations such as lack of adequate power facilities, lack of space for installing a conventional compression machine or high cost of installing such machine, need of vibrationless operations, etc.

The new Carrier absorption machine employs a solution of lithium bromide salt in water—the latter being used as a refrigerant. The boiling point of the salt, which is a solid at ordinary temperatures, is so high that it behaves as a non-volatile substance. Therefore, there is no vaporization of the absorbent in the generator of such a system and no carry-over of absorbent vapor to the condenser. Since there is no need for additional equipment to keep the absorbent away from the refrigerating part of the cycle, the machine remains very simple. At the same time, its efficiency is high since no heat is lost for unnecessary re-evaporation of the absorbent. High efficiency is also assured by the high latent heat of water, which, in fact, is the highest value known for any substance.

All the properties of the solution pertaining to heat transfer, such as density, specific heat, viscosity, thermal conductivity, are well known and are rather favorable. Being non-flammable, non-explosive and physiologically harmless, this solution is especially desirable for air conditioning. Lithium bromide salt is reasonable in cost and readily available.

How the New Machine Works

Arrangement of the machine is shown on Fig. 1. It consists of two

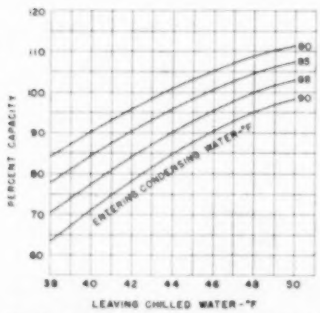


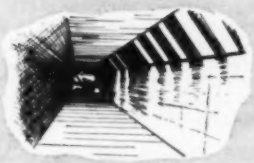
Fig. 2. Typical capacity characteristics of new water vapor refrigeration machine as function of condensing water and chilled water temperatures

WHERE TO USE LUMNITE IN POWER PLANTS

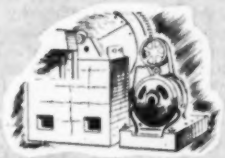
Steel Stack Linings

Ash Pit and Cinder Catcher Linings

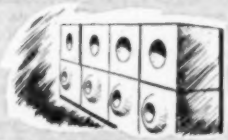
Coal Bunker Linings



Flue and Duct Linings



Overnight Structural Concrete



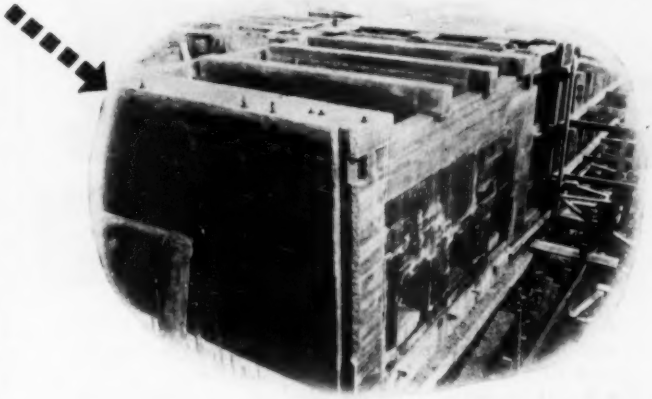
Castable Refractories

Factory-prepared mixtures of LUMNITE and selected aggregates. Mixed with water on the job, cast into place for door linings, arches, baffles, furnace walls. Special shapes can be cast in molds, ready within 24 hours. Castables to meet different temperature and insulation needs are made by manufacturers of Refractories, sold by their distributors.

Tough *LUMNITE Concrete

WITHSTANDS HEAT... CORROSION...WEAR

in self-lined Ash Pit



This combination boiler foundation and self-lined ash pit, built with heat-resistant LUMNITE concrete, is protected against soaking furnace temperatures, corrosion and wear from ashes and cinders.

Monolithic-concrete construction provides smooth surfaces with no joints to wear ragged and tear out. No refractory lining is needed with concrete made of LUMNITE calcium-aluminate cement and crushed fire brick aggregate. Such concrete remains sound and strong under continuous soaking heat from the boiler—it withstands temperatures well above 2000°F.

You also get fast construction with LUMNITE, the rapid hardening cement. Outage time is reduced to a minimum because LUMNITE concrete reaches service strength in 24 hours or less.

In ash pits, cinder catchers, and other power plant installations, as listed in column at left, LUMNITE combines high-early structural strength, high heat- and corrosion-resistance. Lumnite concrete also provides low thermal conductivity when insulating aggregates are used. Send for further information.

**"LUMNITE" is the registered trade mark of the calcium-aluminate cement manufactured by Universal Atlas Cement Company.*

PG-L-13

Lumnite Division

UNIVERSAL ATLAS CEMENT COMPANY

UNITED STATES STEEL CORPORATION SUBSIDIARY

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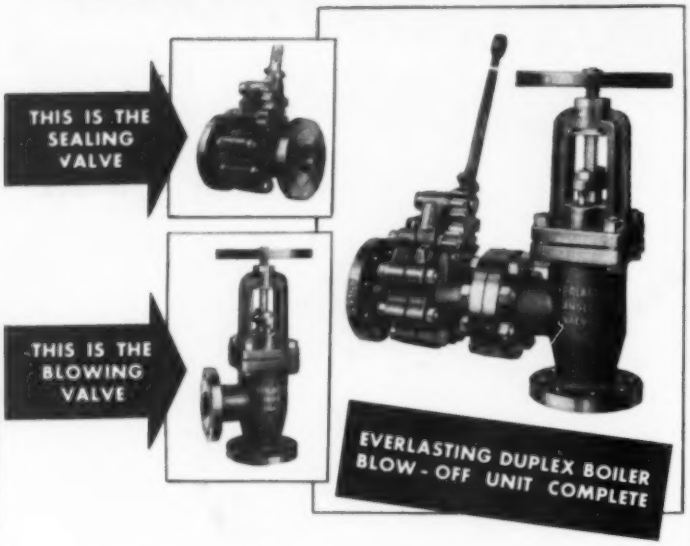
"THE THEATRE GUILD ON THE AIR"—*Sponsored by U. S. Steel Subsidiaries—Sunday Evenings—NBC Network*

CO-ORDINATED FOR BLOW-OFF SAFETY



A "regular" *EVERLASTING* Valve that opens fully with one short movement of the lever . . . a wheel-operated *EVERLASTING* Companion Valve built to take the full punishment of the blow-off . . . these two valves, coupled together, provide a combination that meets full code requirements for dual-valve blow-off.

The lever-operated *EVERLASTING* Valve, designed for unimpeded, straight-through flow, maintains its tight seal, because it re-grinds itself with each operation. It cannot wedge or stick.

The *EVERLASTING* Companion Angle Valve, designed specifically for blow-off service, stoutly resists erosive blow-off water and the abrasive action of solids in such water.

Either valve obtainable separately if desired.

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EV 274A

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shells each comprising two elements; heat exchanger; auxiliaries (solution pump, purge system, eductor); control instruments; and interconnecting piping.

Water to be chilled enters through header (1) and is sprayed into flash evaporator (2). Shell (3) is maintained at lowest absolute pressure nearly corresponding to the temperature to which the water must be cooled. Part of the water flashes, cooling the remainder. It then drains to the suction of the pump (4) which delivers it back to the load. The corresponding pressure in shell (3) is a function of the concentration and temperature of the solution sprayed over absorber coil (5). The flashed water vapor moves down and is absorbed by the solution. The latter thereby is continuously cooled by the flow of condensing water passing through coil (5) to remove the resulting heat of condensation and dilution.

The diluted weak solution is drained from shell (3) into the solution pump (6). This pump delivers a portion of the solution through the heat exchanger (7) to the generator coil (8) located in the upper shell (9). Steam admitted to the tubes boils off the water vapor previously picked up by the solution in the absorber, thus restoring the high concentration of the solution.

Water vapor boiled out of the solution is liquified in the condenser coil (10) by the condensing water passing inside the coil, whereby the same water is used in series through the absorber and condenser. The vapor condensate is returned to the evaporator (2) through loop (11) which acts as a seal against the difference in pressure between evaporator and condenser.

The re-concentrated solution from the generator passes through the heat exchanger (7) and enters into a liquid eductor (12). Here it is entrained by the other portion of the solution from pump (6) and is delivered back to the absorber spray which completes the cycle. The split arrangement reduces the flow of solution to and from the generator and, therefore, the amount of heat to be exchanged in the heat exchanger, making this exchange more complete, and thus securing higher efficiency of the cycle.

Both shells are maintained at a high vacuum, one corresponding to the temperature of chilled water, the other to the condensing temperature. To remove air and other non-condensables, a two-stage purge (13) is provided consisting of steam and water jets with an interstage purge condenser. Two purge lines, one from the absorber and another from the condenser, connect the purge with the shells. Both jets require only a small amount of auxiliary steam and water which is negligible compared to the requirements

PLUGS ARE OUT WITH CHLORINATION

Costly plug cleaning, with its high labor bills and lengthy equipment down-time, goes out of the condenser and heat exchange picture the minute chlorination arrives.

This proven process for cutting the costly effects of back pressure and poor heat transfer characteristics caused by slime, really works, as one Southern Power Station found out when they began using the W&T De-sliming Process. In just six months after W&T Chlorinators were installed, cleaning and excess steam costs were reduced from $1450 per month to $250 per month and a later survey showed an overall saving in excess steam costs of $16000 in a year.

Such savings are indicative of how your condensers may be made to operate more economically and with far less outage when W&T Engineers install chlorination to fight your slime problems.

To learn how chlorination may be profitably applied to your heat exchange equipment and to take advantage of W&T's 35 years' experience, write today.

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UNIONS

of the machine itself. An important point of the purge is that normally only a small amount of water is purged together with the air. The really expensive part of the solution —salt—is not present in the vapor state and, therefore, cannot be normally lost through purging.

The solution pump is a small centrifugal pump driven by a medium speed motor of 5 to 10 hp.

To control the temperature of the chilled water leaving the machine, thermal element (14) is provided in the leaving water line. This element responds to falling temperature at partial load and throttles the solution flow (valve 15) in the whole cycle, thereby reducing the amount of re-concentrated solution coming from the generator. This reduces the absorbing power of the solution sprayed in the absorber, thereby preventing reduction in the evaporator pressure and, consequently, a further drop in chilled water temperature. Another thermal element (16) located in the solution leaving the generator throttles the steam supply (valve 17) by responding to

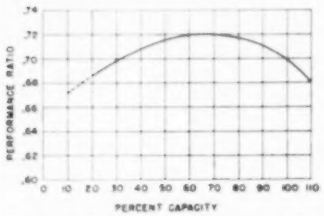


Fig. 3. Performance ratios for new water-vapor absorption machine, for 85-F condensing water entering and 45-F chilled water leaving machine

the temperature rise of solution when its flow is reduced at partial load. The throttling of steam supply balances the output with the input at any load.

Control (18) maintains a constant pressure in the generator-condenser shell by throttling the condensing water to the condenser coil. This, together with the solution temperature, prevents the solution from overconcentrating and holds it at a safe point away from crystallization. The overflow (19), acting as a trap, maintains a constant level of solution in the generator, thus securing a proper distribution of the solution in the whole unit. Several safety controls are provided to protect the unit against any accidental overconcentration and solidification. They automatically shut down the machine by closing off the steam supply when the situation becomes dangerous.

Controls are pneumatic and completely automatic. They regulate chilled water temperature within 3 to 4 deg over a range of load variation between 100 and 10 per cent of full capacity.

The machine is now being offered

In Plant After Plant—

One of America's Largest Auto Manufacturers Has Selected MULTICLONES for Fly Ash Recovery!

Over 35 MULTICLONE Units To Date in Various Plant Divisions!

A Few of *Many* MULTICLONE Advantages!

POINT 1 —It Saves Space!

Plant space costs money. Because the Multiclone makes *really* important savings in space, it makes similar savings in plant costs. The chart tells only part of the story because, in addition to being far more compact both in square and cubic footage, the shape of the Multiclone can be adjusted to fit various space requirements—either long and narrow, short and wide, or square. You can often fit the Multiclone into tight spaces or waste areas too small for other equipment!

Make	Relative Space Requirements In Sq. Ft.	In Cu. Ft.
Multiclone	1.0	1.0
Collector A	2.1	1.8
Collector B	5.9	3.2
Collector C	6.8	3.9

POINT 2 —It Recovers the "Fines"!

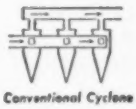
Because its exclusive vane design and small diameter tubes generate higher centrifugal forces, the Multiclone recovers a large percentage of even the very fine particles 10 microns and less as well as the heavier particles. Multiclone's high recovery of both small and large particles means high overall collecting efficiency.

POINT 3 —It is Unusually Adaptable!

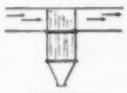
In addition to the shape adaptability outlined above, Multiclone's inlet-outlet connections are also readily adaptable to plant restrictions. Where headroom is low, install the Multiclone with side-inlet, side-outlet. Where side clearances are small, use side-inlet, top-outlet arrangement. Or still other arrangements are possible!

POINT 4 —It is Simple!

Both installation and maintenance of the Multiclone are unusually simple. For example, the Multiclone requires only a *single* inlet and a *single* outlet duct compared with the complicated multiple ducts of conventional cyclones. This not only saves space—but is simpler and cheaper to install and insulate. Moreover, the Multiclone has no filters to replace, no high-speed moving parts to maintain, nothing to require frequent cleaning or repair . . . and a *single* collecting hopper serves many tubes!



Conventional Cyclone



Multiclone

POINT 5 —Still Other Advantages!

The above advantages are by no means the complete story on Multiclone savings. Get *all* the facts before you decide on *any* recovery installation.

Send for this Multiclone booklet!

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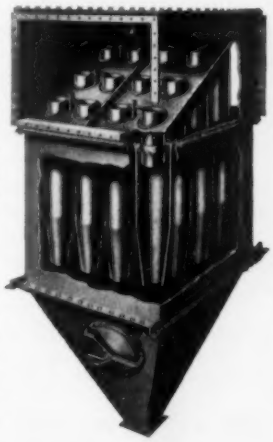
YEAR AFTER YEAR—in plant after plant—one of the nation's largest automobile manufacturers has selected Multiclone Collectors for recovering fly ash and dust in its many manufacturing divisions. This repeated selection of Multiclones—now totalling over 35 units—is high testimony to the many vital advantages found in Multiclone equipment. Check over some of these advantages as outlined at left . . . advantages that will save space—cut installation costs—boost recovery efficiencies—minimize maintenance and make other important savings on *your* recovery operations, too.

Then consider this fact . . . Any *one* of these advantages is sufficiently important in itself to make Multiclone equipment the logical choice for your recovery operations. But when you realize that the Multiclone offers definite, clear-cut advantages on *every* qualification essential to maximum efficiency and economy in recovery operations you have some idea of the far-reaching savings you will make by installing Multiclone.



Let us give you further information on Multiclone recovery equipment. A letter, wire or phone call to our nearest office places the information in your hands without obligation. Get *all* the facts—and you'll get Multiclone!

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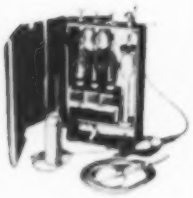

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HAYS PORTABLE GAS ANALYZER

Every power plant needs this handy Hays Portable Gas Analyzer or Orsat. It gives you a quick, accurate test of flue gases for CO_2—one of the best known ways to measure the efficiency of your fire. It also serves as a check on your CO_2 Recorder.

Hays offers several styles from which to choose—from the single chamber to the multiple unit that analyzes for CO_2, O_2 and CO. All sizes immediately obtainable. Send for new catalog (Publication 47-668) and the helpful booklet "The A-B-C of CO_2."

or automatic

HAYS CO_2 RECORDER

To most boiler room operators this is the dependable "stand by"—the Hays CO_2 Recorder or Combustion Meter, permanently mounted and automatic. Every two minutes throughout the 24 hours it makes a combustion analysis and records its findings on a 10-inch chart. It also records draft and flue gas temperature. The Hays Combustion Meter operates entirely by water on the true Orsat principle of volumetric measurement and chemical absorption—and is virtually infallible. Its interesting story is in Publication 47-550—send for it.

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MICHIGAN CITY, INDIANA, U.S.A.

in five different sizes ranging in capacity from 100 to 350 tons. Full condensing water flow requires 3½ gpm per ton; however, reduced flow is permissible with some sacrifice in capacity. Flow of chilled water is not critical, and can be normally established anywhere between 1½ to 3 gpm per ton.

Efficiency of the machine is conveniently expressed in terms of performance ratio:

$$R = \frac{\text{Useful refrigerating effect, Btu per hr}}{\text{Heat input, Btu per hr}}$$

The performance ratio for the new machine is shown in Fig. 3. It increases at partial loads reaching the maximum at about 70 per cent capacity. This is because the heat exchanger becomes more effective when the solution flow is reduced at partial load. Corresponding value of performance ratio for the ammonia-water machine used at the same conditions will be somewhere between 40 and 45 per cent.

From Fig. 3, steam consumption can be easily determined. Adding about 2 per cent for safety, the consumption is about 19 lb per ton per hr at full load and 18½ lb per ton per hr at 70 per cent load.

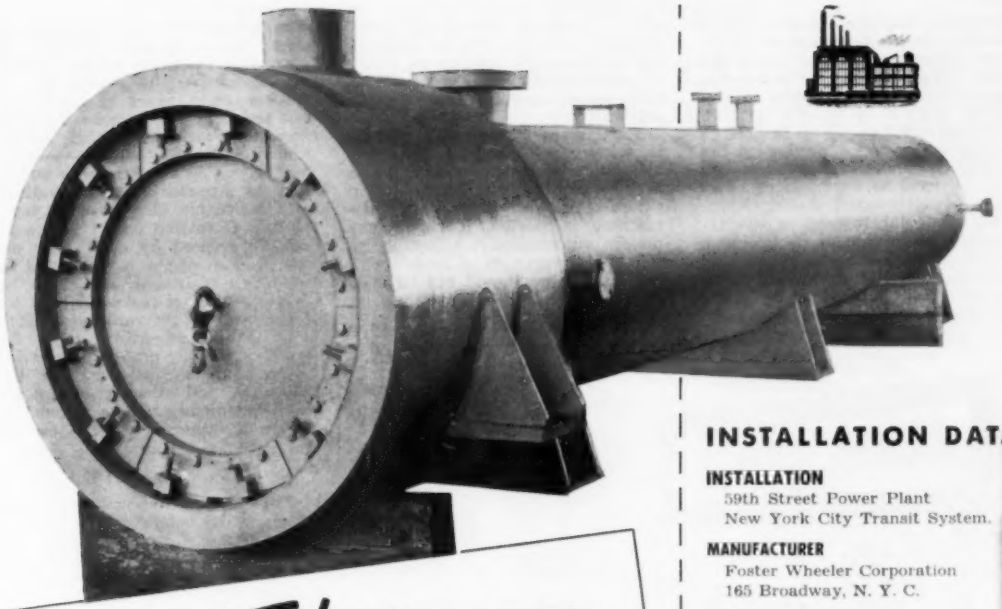
The machine is designed to give full capacity at steam pressures of 12 psig or higher. Lower pressures can be used with some sacrifice in capacity. Since the steam consumption of the machine is a function of latent heat, it is practically independent of pressure. See Table I.

In case the steam condensate is returned to the boiler or is used in some other way, this machine deserves special credit for an additional saving in fuel. Since the temperature of the condensate from this machine is from 100 to 200 F higher than in the usual steam condenser, a corresponding amount of fuel is saved in the boiler. The saving amounts to between 10 and 20 per cent.

Application

Due to compactness, comparatively light weight, absence of vibration, and safety of operation, the machine may be conveniently located in practically any part of a building, whether basement, attic, roof, or intermediate floor. The preferred location is above the chilled water coil, so-called top location, because it completely elminates any danger of flooding the machine by chilled water and because it requires a smaller pumping head on the chilled water pump since in this case it has to overcome only friction.

Heat to be dissipated from this absorption machine is about twice as great as for an electrically driven compression machine. However, it does not require twice as large a cooling tower, since for the same amount of condensing water used in both machines, the temperature rise of condensing water through the



Monel Tubes have many advantages in Boiler Feed-water Heaters

Foster Wheeler Corporation designed and built the above boiler feed-water heater (and a mate) for the 59th Street Power Plant of the New York City Transit System, to specifications set by Burns and Roe, Inc.

And into each heater went 550 Monel® U-tubes . . . *insurance for long, efficient service.*

Here are some of the reasons why Monel was specified in place of more commonly-used metals:

1. Higher mechanical properties . . . which means better heat transfer because lighter gauges can be used.
2. Better all-'round corrosion resistance . . . which means longer life, fewer failures, less "downtime."
3. Greater hardness . . . which means better resistance to erosion and cavitation. And when tubes stay smooth, you get faster flow, better heat transfer.
4. High ductility . . . which means tight rolled joints in tube sheets, and ease of forming bends in U-tube heaters.
5. Easy weldability . . . which means conventional welding techniques can be used to weld the Monel tubes into the steel tube sheet, if welding is specified.

Consider Monel the next time you design, install or re-tube a heater. No other metal offers so many advantages for this use. For more information on Monel heater tubes, write to P. F. Sheridan at Inco.

INSTALLATION DATA

INSTALLATION
59th Street Power Plant
New York City Transit System.

MANUFACTURER
Foster Wheeler Corporation
165 Broadway, N. Y. C.

SPECIFICATIONS
Burns and Roe, Inc.
233 Broadway, New York 7, N. Y.

TUBE DETAILS
Each heater has 550 Monel U-tubes, ⅝" O.D., 17 B.W.G. (.058" wall).

LOCATION
Two of the illustrated, closed-type, Monel-tubed feed-water heaters will be installed between boiler feed pump and boiler. (Three direct contact heaters are in the line before the feed pump.)

OPERATING CONDITIONS
950° F., 1250 psi at turbine throttle.

FIRST-STAGE MONEL-TUBED HEATER
Uses 450 psi, 680° F. bleed steam in shell. Outlet water temperature: 421.4° F.

SECOND-STAGE MONEL-TUBED HEATER
Uses 900 psi, 860° F. bleed steam in shell. Outlet water temperature: 515.1° F.

WATER PRESSURE IN HEATER TUBES
2000 psi design.

WATER VELOCITY THROUGH HEATER TUBES
3.97 feet per second.

CAPACITY OF HEATERS
693,000 pounds of water per hour.

EMBLEM OF SERVICE
INCO
TRADE MARK

THE INTERNATIONAL NICKEL COMPANY, INC. • 67 Wall Street, New York 5, N.Y.

absorption machine is higher, which permits a larger temperature difference between water and air in the tower. Therefore, the net increase in tower size is only between 10 and 20 per cent.

A number of units can be used in parallel or series connection on the chilled water side. The machine can also be used to complement other types of refrigerating machines.

Of particular interest is the attractive steam rate of the machine at low steam pressures. When high pressure steam is available, further economy can be realized by using the steam first for power generation to drive pumps, centrifugal compressors, or generators by expanding it through a turbine to a low exhaust pressure, and then re-using and condensing it in the absorption machine.

Starting and stopping the machine is a simple operation requiring about the same number of steps as is needed for electrically-driven centrifugal compressors. After the machine is started, it runs completely automatically, adjusting itself to any variation of load.

The machine should not be used in an open chilled water circuit, such as with an air washer, because of an excessive amount of air picked up by the water sprays. Where an air washer is used, a water-to-water heat exchanger is recommended.

After eight years of laboratory test and field observations, the most important facts established so far are: the lithium bromide solution has proved to be chemically stable, and its properties do not undergo any noticeable change after years of use. Corrosive action is practically prevented by controlling the specification of the solution and its inhibiting treatment, as well as by careful choice of materials used for construction of the various elements.

Direct connection with the machine actually protects the chilled water piping against corrosion, because air and other gases are almost completely removed from the water by purging while passing through the evaporator.

Economics

First cost of the new absorption machine is competitive with the other types of water chilling machines in the tonnage range for which it is designed. For this range of capacity, steam is available in practically all cases either from the local boilers installed for heating or from a district steam plant.

Operating expenses for the machine can be easily figured out on the basis of the steam consumption given above and the local cost of steam and power. When making an economic comparison with other machines, the difference in cost of non-identical items like different sizes of cooling tower, power wiring, steam piping, machine foundations, floor reinforcement, etc., should be taken into account. Comparison in operating cost should include the cost of power for driving all pumps and fans which are not identical in power consumption.

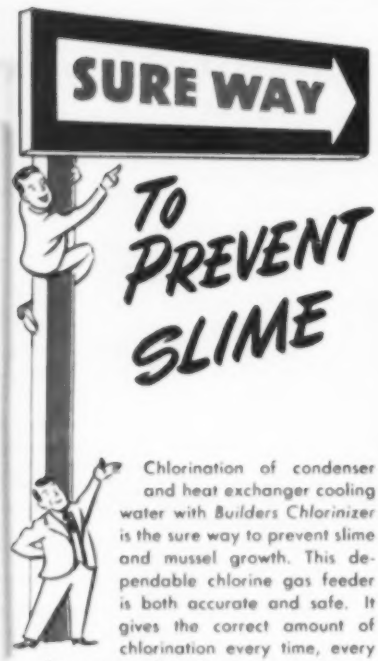
The break-even point in operating cost between this machine and the electrically-driven compression machine occurs at approximately the following ratio:

$$\frac{\text{Steam cost, \$ per M lb}}{\text{Power cost, \$ per kwhr}} = 50$$

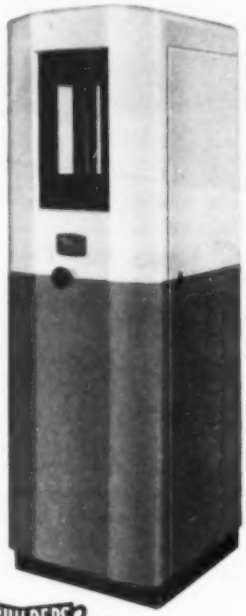
That is, wherever the cost of steam in \$ per M lb is less than 50 times the cost of electricity in \$ per kwhr, a lower operating cost should be expected for the absorption machine.

Regarding the maintenance cost, the experience accumulated so far indicates that it should be equal to or lower than other types of refrigerating machines. The main items of maintenance are cleaning of the heat transfer surfaces and filtering the solution every year or two.

THE APPOINTMENT of John A. Menster as assistant manager of sales for the Welded Tube Division of The Babcock & Wilcox Co., effective April 2, was announced by L. E. Jeanneret, manager of sales.



Chlorination of condenser and heat exchanger cooling water with *Builders Chlorinizer* is the sure way to prevent slime and mussel growth. This dependable chlorine gas feeder is both accurate and safe. It gives the correct amount of chlorination every time, every hour, every day. For intermittent operation, the *Chlorinizer* holds its vacuum—keeping the feeder in readiness to start chlorination the instant it's needed. There's no delay . . . no waiting to establish a new vacuum . . . no auxiliary injectors to waste water during off-feed periods. The direct-reading Sightflo indicator shows actual rate of chlorine delivery—positive assurance that chlorination is up to specifications. For Bulletins and engineering information, address Builders-Providence, Inc. (Division of Builders Iron Foundry), 385 Harris Ave., Providence 1, R. I.



BUILDERS *Chlorinizers*

The chlorine gas feeders with extra features

Builders makes a complete line of flow meters and controllers for liquids, steam, air, gas, and dry materials . . . mechanical and differential . . . including The Venturi Meter and Chlorinizers (chlorine gas feeders).

130 YEARS
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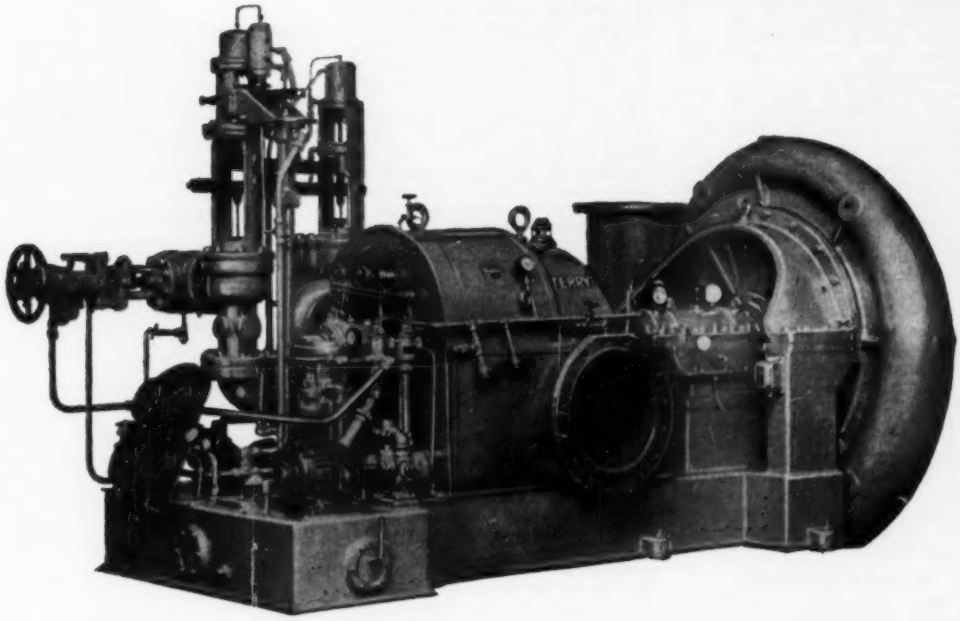
BUILDERS IRON FOUNDRY

BUILDERS PROVIDENCE
Instruments

The TERRY TURBINE



SPECIAL PURPOSE TURBINE

FOR OPERATION UNDER ALL THESE CONDITIONS:

1. Straight, high-pressure, condensing
2. Straight, low-pressure, condensing — putting to work excess low-pressure steam.
3. Mixed pressure — using the low-pressure steam available, with only enough high-pressure steam required to drive the compressor
4. Condensing bleeder operation — providing clean, low-pressure steam for heating or process work

. . . and the speed under any of these conditions can be varied from 2800 to 4750 rpm.

This is but one example of many unusual combinations developed by Terry to meet out-of-the-ordinary requirements in turbines up to 2000 hp. Information on a special-purpose turbine for your specific requirements will be gladly furnished.

T1177

THE TERRY STEAM TURBINE COMPANY
TERRY SQUARE, HARTFORD, CONN.

WATER-COOLING TOWERS

(Continued from page 69)

hazards are increased considerably. Water-cooling towers operated in sub-freezing weather are subject to ice formation on the louvers and the outer portion of the filling. To prevent icing in cold-weather operation, the cold-raw water (tower circulating water) temperature should be maintained as high as practical, taking into consideration the effect upon the economy of the equipment served.

One or more of the following procedures are recommended for induced draft towers: (a) Run two-speed motors on half speed; ice formation may be retarded and fans will require only about 15 per cent of the power used at full speed; (b) shut down fans completely, this may retard ice formation; (c) cover upper portion of louvered area; (d) reduce water flow to the tower and shut off some of the cells; (e) by-pass the cooling tower with part of the water and shut off some of the fans or cells of the tower.

If ice should form on the louvers and filling, one of the following methods of removal could be used: (a) Reversing (for a limited time) the rotation of the motor driving the fan and thus blowing the warm air backwards and out through the louvers. (b) Shut down some fans temporarily but do not shut off water. (c) Cover upper portion of louvered area.

Mechanical Maintenance

A regular schedule should be set up for the mechanical maintenance of cooling tower equipment. See Table I. Well maintained equipment gives the best operating results and the least over-all maintenance cost. Ball bearing motors should be greased with an approved water-resistant grease every one to three months. Follow instructions issued by the motor manufacturer when greasing motors. Do not overgrease ball bearings, for over-greasing will cause their failure almost as quickly as undergreasing. Insulation value of the motor should be checked yearly.

Drain out the old oil and refill speed reducers with clean oil of the proper grade every 3000 hours of operation, or at least twice a year. The proper grade of oil for the speed reducers is usually shown on the nameplate. Excessive clearance or play between pinion and ring gears indicates wear. End play of the pinion shaft or side play of the fan shaft shows bearing wear. Oil leaking around the pinion shaft or fan shaft indicates that the oil seals are worn and should be replaced.

Paint fan hubs as often as necessary to prevent corrosion. Corrosion difficulties vary considerably depending on the nature of the water used in the tower and the atmosphere at the point of installation. Tighten all blade clamps and hub bolts, and re-balance when necessary.

Structural Maintenance

Remove all dirt, scale, bugs, and debris from the distribution system. Replace all damaged or missing parts. Clean and paint all corrodible metals as required. Redwood does not require protection from the weather, but in some cases it may be desirable to paint it for appearance. Tighten all loose bolts, making allowance for the swelling of wood when wet.

Drift eliminators should be cleaned when appreciably dirty. Dirty eliminators reduce air flow through the cooling tower. Eliminator spacers should be aligned. When installing eliminators do not leave holes between eliminator bundles, or between ends of bundles and adjacent members, as these spaces would allow excessive drift. When wood filling slats become dirty they should be cleaned. Replace broken or badly warped slats, maintaining the same "pattern" or spacing of slats both vertically and horizontally as in the original installation.

Shutting Down

When a cooling tower is to be shut down for an appreciable time, particularly in cold weather, it should be drained to prevent damage from freezing and corrosion. Leave the drain open to allow rain and melted snow to escape. Operate the fans for a period of approximately five minutes once a week to keep the upper fan shaft bearing oiled. Protect metal parts from corrosion.

Maintenance or repair work should be done while the cooling tower is completely shut down, if possible. This gives the best opportunity for inspection and maintenance and does not restrict the operation of any of the equipment served. A properly maintained and efficient water-cooling tower is one of the most important factors in a modern plant requiring cooling water and will greatly improve the over-all efficiency of the process involved.

IMPULSE WATER TURBINES

(Continued from page 106)

flector servometers, deflector linkages, and needle servometers are all readily accessible from the two turbine operating floor levels.

For runner removal, a hydraulic cylinder is placed at the hollow 6-in. bore of the shaft and used to raise and lower the rotating element as required. The wheel can then be easily brought out of the pit, via the tailrace and suitable access holes provided to the main generator floor level for maintenance work, holding turbine outages to a minimum. Time for taking turbine off line, removing runner, installing spare runner, and returning turbine to line, is about 16 hours.

It is believed that the 70,000 hp being taken from each of the Bridge River turbines now in operation represents the maximum horsepower ever obtained from a single impulse runner, and the very small maintenance thus far required is very encouraging.

HELPFUL BULLETINS

(Continued from page 36)

130 **Tube Cleaners**—Bulletin G-515 is a small 6-pp folder describing and illustrating air and water driven tube cleaners for straight and curved tubes, air driven cleaners for large tubes and pipes and cleaners designed for use on small tubes. Discusses cleaner heads and motors and also lists hose and other accessories. Roto Div., Elliott Co.

MISCELLANEOUS

131 **Inspection Chart**—Faulty fire extinguishers aren't found around plants where extinguishers are inspected regularly. To make the job simpler this handy inspection form is offered. It's ready to be filled in with types, numbers of extinguishers, their location, dates of inspection and recharging and inspector's comments. On stiff paper, chart may be folded and filed or hung on a wall. Ansul Chemical Co.

132 **Air Recovery Cells**—Bulletin 117-C, 16 pp, presents company's activated carbon air-recovery cells for air conditioning systems and units, to purify air, improve ventilation, save cooling and heating. Tells briefly the purpose, function, application and operation of this type of air cells and discusses its use of activated carbon, also its role in ventilation. Illustrates and gives specifications for air recovery equipment and shows typical assembly arrangements. Includes capacity and resistance curves, cost comparison figures. W. B. Connor Engineering Corp.

133 **Vibration Control Materials**—Characteristics of the various types of vibration isolation media are given in Catalog G-102, 4 pp. In it, 50 typical machine and equipment applications are tabulated in chart form with recommendations for proper types of vibro-isolators for highest efficiency, and with alternates for satisfactory operating efficiency for less exacting requirements. Various types of standard mountings are described with data for loading ranges which run from 10 to 50,000 lb per isolator. Specific purpose isolators and other applications are also described. The Korfund Co., Inc.

134 **Rust Prevention**—Here's a 6-pp engineering data sheet dealing with the arrest and control of rust on transmission towers, power stations and other utility equipment, a subject of vital interest to power engineers. The report, while based on the findings of years of study by engineers and technical specialists, is presented in layman's language, clearly illustrating and describing the causes, effect and means for control of rust. International Rustproof Corp.

135 **Cranes for Power Plants**—This unusually pictorial 8-pp bulletin, Sec. 300, Unit 73 is on cranes built by manufacturer for service in the utilities industries. Illustrates the variety of cranes used in the power field and includes a list of over 350 powerhouse crane installations. Whiting Corp.

136 **Flexible Hose**—Illustrated Bulletin SS-1, single page, is devoted to flexible stainless steel hose for use under extremely high temperatures, and for conveying under pressure or vacuum, materials corrosive to many types of hose. Illustrates open and close wound, braided and unbraided types. Gives specifications. Johnson Metal Hose Inc.

137 **Corrosion-Resistant Alloys**—This new edition of company's 40 pp booklet on high-strength, nickel-base, corrosion-resistant alloys, tells the story of the four Hastelloy alloys—what they are, how they can be fabricated and how they can be used to combat severe corrosion. In addition to a brief description of each of the alloys, there are tables showing their resistance to common corrosive media. Their

The *Maxiflow* has all 3 · · ·

CAPACITY
PERFORMANCE
ECONOMY

Incorporated in Consolidated Maxiflow Safety Valves are design and performance advantages that are the results of over 70 years of valve manufacturing experience.

MAJOR FEATURES INCLUDE—

The Thermodisc—Designed to permit rapid equalization of temperature differentials set up when a high-pressure safety valve reseats after blowing. Thermal stresses are minimized. Seat distortion cannot take place. Permanent tightness is achieved.

Mechanical Through Bushing—Precision machined surfaces provide constant entrance conditions for steam flow. Eliminates leakage due to porous castings. Selection of material with high strength and creep resistance values at elevated temperatures is made possible. Added strength in the valve neck is also obtained.

Control of Blowdown—The Maxiflow has been specifically designed to function with a blowdown as low as one (1) per cent. The exclusive "micrometer" trim ring provides a simple and practical chatterproof blowdown control—externally controlled and can be made with valve under pressure.

Retention of Popping Point—Change in the popping point, due to temperature difference, is held to a minimum in the Maxiflow. This is achieved by combining proper compensation with materials having low coefficients of expansion. Special alloy steel is used to obtain stability of spring support in the yoke rods, and the stainless steel spindle compensates thermally for elongation of other parts which would affect spring loading.

Consolidated Maxiflow Safety Valves are available in either welding or flanged inlet.

Pressure range is from 250# to 2500#. Temperatures to 1100° F.

For a complete description plus capacity tables, write for the Consolidated Maxiflow Safety Valve Bulletin.

CONSOLIDATED *SAFETY* VALVES

A Product of

MANNING, MAXWELL & MOORE, INC.
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Makers of 'Consolidated' Safety and Relief Valves, 'American' Industrial and 'Microsen' Electrical Instruments, 'Hancock' Valves, 'Ashcroft' Gauges. Builders of 'Shaw-Box' Cranes, 'Budgit' and 'Load Lifter' Hoists, and other lifting specialties.

strength, toughness and machinability are given in tables that include properties at room temperature and at elevated and sub-zero temperatures. Graphs compare their properties with those of other common construction materials. Uses of available forms are discussed and working procedures given. Haynes Stellite Div., Union Carbide and Carbon Corp.

138 **Feeder-Weigher**—Bulletin 3849, 6 pp is devoted to manufacturer's feeding and weighing unit for stream delivery of small, crushed, granular or non-flushing ground materials, and consisting of two belt conveyors. Discusses accuracy and applications of the unit and includes specifications, dimensional data, photos and blend diagram. Richardson Scale Co.

139 **Industrial Cylinders**—Bulletin 500, 12 pp, gives dimensions and weights, ratings and limitations of company's new medium-duty line of cylinders for operation by air, oil, water or steam, and provides same information for heavy duty and super duty cylinders. Factors affecting the selection of cylinders are presented, along with illustrations and designs of rod and head attachments. Also describes completely cylinders, rod and head attachments which are available from stock. Ledeen Mfg. Co.

140 **Conversion Table**—Data Card TDC-110A is a linear conversion table for handy reference by engineers who frequently wish to convert inches and fractions of inches into decimal parts of a foot. It is suitable for many purposes in addition to those encountered in the application of steel tubing. The Babcock & Wilcox Tube Co.

141 **Dry Dampers**—Illustrated with layout diagrams of typical reversing damper and seat assembly and a stack damper and guide assembly, 4-pp Bulletin FD-49 stresses uniform draft and temperature control and other features of company's dry dampers. The Ohio Steel Foundry Co.

RODA

High grade gas, by-product, steam and household stoker coal from Wise County, Virginia, on the Interstate Railroad.

CRITERION COAL

High grade gas, by-product, steam and domestic coal—Pittsburgh seam from Irwin Basin, Westmoreland County, Pennsylvania, on the Penna. Railroad.

DENDRON

High grade gas, by-product, steam and domestic coal from Wise County, Va., on the Interstate Railroad.

HAMPTON COAL

High volatile domestic, steam and by-product coal from Boone and Logan Counties, W. Va., on the Chesapeake & Ohio Ry.

STONEGA

High grade, high volatile steam and by-product coal from Wise County, Va., on the Interstate Railroad.

CROZER

Genuine Pocahontas from McDowell County, W. Va., on the Norfolk & Western Railway.

PREMIX

A laboratory controlled product blended to meet exacting stoker requirements. From Wise County, Va., on the Interstate Railroad.

LYNCO

High fusion coking coal for by-product, industrial stoker and pulverizer use from Wyoming Co., W. Va., on the Virginian Ry.

GLENBROOK

The Premium Kentucky High Splint unmatched for domestic use. Produced in Harlan County, Kentucky, on the L. & N. Railroad.

COKE

Roda and Stonega from Wise County, Va.

ANTHRACITE

Hazle Brook—*Premium Lehigh*
Raven Run—*Premium Mahanoy*

Capable engineering personnel and the experience gained through long and varied marketing activity assure proper application of one of the above brands and effective servicing of any fuel requirement.

General Coal Company

123 SOUTH BROAD STREET, PHILADELPHIA 9, PA.

BRANCHES:

BLUEFIELD, W. VA. BUFFALO CHARLOTTE, N. C. CINCINNATI
NEW YORK NORFOLK PITTSBURGH

UNDERGROUND COAL GASIFICATION

(Continued from page 102)

tainable at the project has been used. The experiment may later reveal that higher pressures and greater volume are needed under certain conditions.

4. At times during the past two months the *calorific value* of the product gas has been high enough to be combustible under proper conditions. Due to by-passing of air through void spaces underground, the energy content in the coal has largely been obtained as sensible heat from the gasses evolved from the system. We have reasonably good evidence that a good quality air-blown producer gas is being made on the burning coal ribs, but it has not yet been possible to produce such gas above ground. It is believed that this can be accomplished by additional drilling and introduction of sand at the proper point.

5. In order to obtain data regarding the effect of heat on the overlying strata, test holes have been drilled along the line of the original entry and some to the side. It was found in some instances that the strata 15 ft above the top of the coal show the effect of heat. Some of the cuttings obtained from the test holes were red in color, similar to the red rock of burning culm or refuse piles.

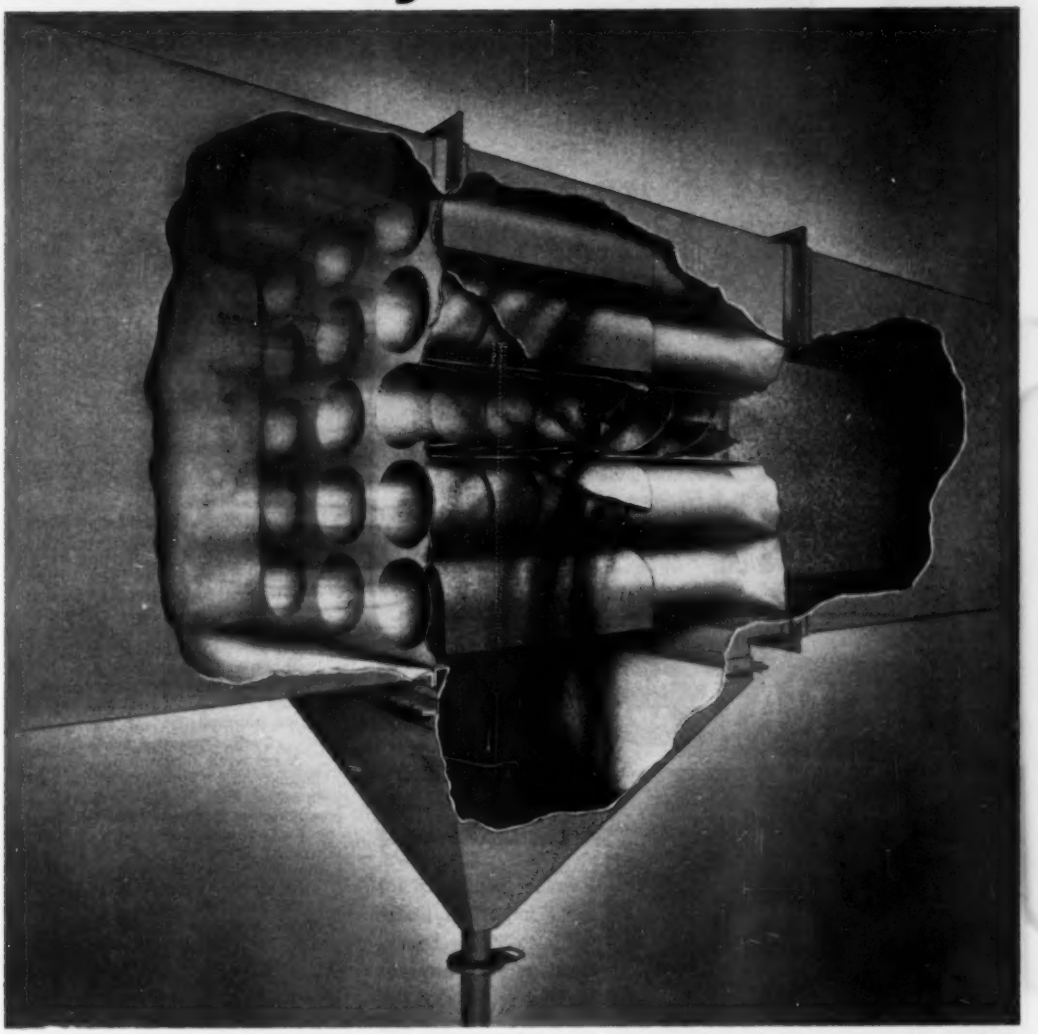
The test holes to the side or off from the original entry indicate that there are few if any void spaces either at coal bed level or in the overlying strata. At the level of the coal bed, drill cuttings show the presence of some combustible material. However, the volume in this region is at least three-fourths rock and material whose physical properties have been altered by the action of the heat. The evidence is that the roof action away from the line of the original entry is altogether favorable to the process of underground gasification, and the roof action along the line of the original entry was not favorable. This strengthens the theory that either a sufficiently high temperature was not maintained, or that the rise of temperature during the first stage of the experiment was not sufficiently rapid.

6. The acquisition of technical and economic information which can be useful in the selection of plant sites, plant installation and operating processes, will be gradual and cumulative. These data can be gained as experiments are made, and without interfering with fundamental objectives. For example, some valuable knowledge of seals has been acquired.

Conclusions to be Drawn

It is no exaggeration to state that some of the purposes of the experiment as originally proposed have been attained, and that the experi-

Whirlex Fly Ash Arrestors



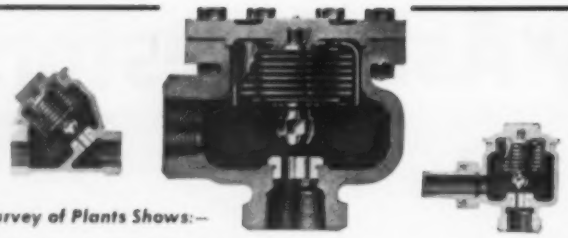
THE HIGHLY EFFICIENT truncated cone type fly ash collector element, from which the collector pictured above was assembled, consists of a triple flight, oblique, helicoid followed by a series of truncated cones. The leading edges of the cones are chamfered and the units are mounted to provide efficient escapement clearances around the periphery. Designs are based on a full load velocity of 2500 feet per minute. Since erosion from gas-borne solids is not a serious factor at this speed, a resulting long and MAINTENANCE-FREE arrestor life can be anticipated. At maximum velocity each tubular element has a gas capacity of 1194 cubic feet per minute with a water gauge draft loss of 1.65". Each element occupies 12" horizontal) x 11" (vertical) cross-sectional area. The single stage horizontal arrestor shown above is one of several arrangements in which this VERSATILE element can be used. Arrangements include single and double stage arrestors for horizontal, inclined, and vertical runs of breeching, as well as special package units assembled complete with induced draft fan, stub stack, and support structure.

For more complete information, write for general catalogue.

THE FLY ASH ARRESTOR CORPORATION

BIRMINGHAM ALABAMA

P.O. Box 1883 Phone 54-6676

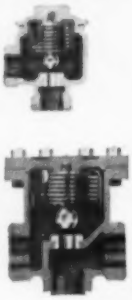


Survey of Plants Shows:—

15 of 20 Engineers Prefer Nicholson Traps

To determine the best steam trap on which to standardize, a large processing firm recently asked their plant engineers for their preference. In 15 out of 20 plants the choice was Nicholson.

The repeated adoption of Nicholson steam traps in plants currently in big "cost-reduction-through-modernization" programs is another indication of their advanced features. To learn why an increasing number of leading plants are standardizing on Nicholson thermostatic steam traps send for our catalog. 5 types for every power, heat, process use; size ¼" to 2"; press. to 225 lbs.



Catalog 250 or see Sweet's

W. H. NICHOLSON & CO. 160 OREGON STREET WILKES-BARRE, PA.

ELIMINATE WHEELBARROWING AND SHOVELING

BIN-TO-STOKER SCREW CONVEYOR

Release manpower for more important duties —Bin-to-Stoker Direct-Feed Screw Conveyor handles up to 1000 lbs. per minute . . . Self feeding . . . Compact . . . Quickly adaptable to any boiler room. Saves time—labor—money. Write for our Bulletin No. 121.

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ment thus far may be regarded as successful. None of us who are connected with the work are under any illusion as to the difficulties which have yet to be overcome. There are many variables and many approaches.

Ideas for Getting More Air Into Coal

It would, indeed, be progress if some measure of independence of roof action can be demonstrated. A process of fracturing the strata has been successfully applied to oil sands to make them more permeable. If this process can be adapted to coal strata, which are much more friable, or to the strata below or above the coal, it may be possible, by drilling two holes at some interval to be determined and by forcing air from one hole to the other, to burn out the area between and adjacent to them. This method, patented by the Stanolind Oil and Gas Co., has increased the flow from oil sands from some thirty oil wells at depths as great as 7500 ft below the surface. This process will be tried during the course of the experiment to make possible the full flow of air between the holes.

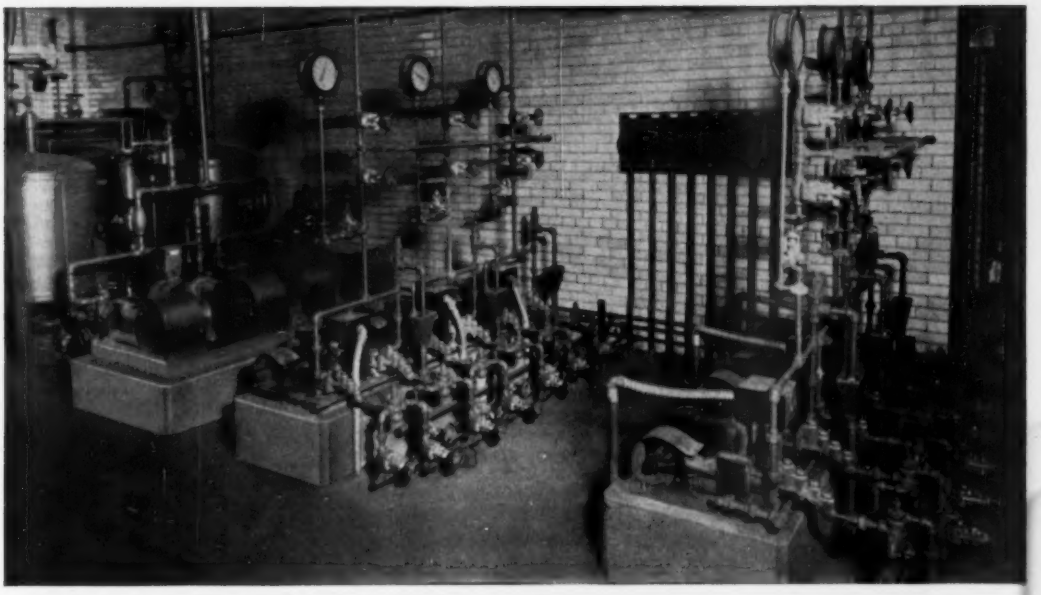
Another possibilty is horizontal drilling. It is reported that when a large chemical company performed its underground gasification experiments in a coal bed in West Virginia, a horizontal hole three feet in diameter was drilled 700 ft in length in a five-foot seam of coal. And had it not been for an obstruction in the coal bed in the nature of a fault, the hole would have been continued on to the 1100 ft, which was the distance planned.

Cyclic Operation Suggested

A research director of one of the largest coal companies holds to the opinion that by separating two worked-out areas in abandoned mines, where the pillars remain, a cyclic operation can be attained similar to that which prevails in retorts in gas manufacture. His idea is to heat one such area to some given temperature by firing, and then introduce steam into this area while a second area is being brought to the predetermined temperature. In this manner a synthesis gas may be made continuously, and the energy contained in the coal in abandoned mines be produced in a useful form.

Those interested in the experiment welcome any suggestion which holds possibility for making the underground gasification of coal a practical process. They are positive on one point; this job needs to be done for the future security of Americans and for the benefit of people everywhere.

(A different technique, called "electro-carbonization," has been subjected to field tests by the Missouri School of Mines on coal properties of the Sinclair Coal Co. High voltage electricity dispatched through an unmined seam of coal has produced a gas of 500 to 600 Btu heating value, it is claimed.—Bituminous Coal Institute.)



FOR BOILER WATER CHEMICAL TREATMENTS

Specify

- **Milton Roy Chemical Pumps**
- **Milton Roy Chemical Feed Systems**

Proof of "Performance" in chemically treating boiler water are the many installations of Milton Roy equipment in modern utility and industrial power plants . . . both complete Milton Roy "Packaged" Systems engineered for specific applications and Chemical Pumps as components in systems developed by plant engineers. In the plants listed below typical installations of such equipment have been made in recent months.

SPRINGS COTTON MILLS, GRACE, S. C. (Complete packaged systems, including tanks and accessories, for handling both sulfite and phosphate feeds.)

ESSEX (NEWARK) GENERATING STATION, PUBLIC SERVICE ELECTRIC & GAS CO. (Pumps.)

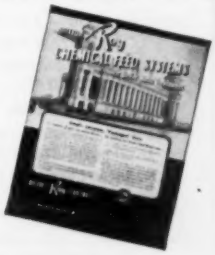
LANSING (MICH.) STATION, INTERSTATE POWER CO. (Pumps and tanks for feeding sulfite and phosphate.)

EAGLE POINT WORKS, TEXAS CO., WESTVILLE, N.J. (Pumps.)

MANSFIELD TIRE & RUBBER CO., MANSFIELD, OHIO (Pumps.)

SOUTHWARK STATION, PHILADELPHIA ELECTRIC CO. (Packaged systems, for feeding sulfite and phosphate. Shown above.)

Milton Roy Packaged Systems include all necessary pumps, solution tanks, covers, gage glasses, low level cutouts, alarms and motor starters. They can be supplied with automatic electronic controls to operate pumps at speeds proportional to feed water flow as measured by a flow meter. Available to handle all treating chemicals and in capacities to meet all pressure and capacity requirements.



Details in Bulletin 451 . . . ask also for Technical Paper 51 "What the Power Engineer Needs to Know About Chemical Feed Systems."

MILTON Roy COMPANY

1320 E. MERMAID LANE, CHESTNUT HILL, PHILA. 18, PA.

Paracoil EVAPORATORS

for STATION HEAT BALANCE or FRESH WATER SUPPLY

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LETTERS TO THE EDITORS

(Continued from page 53)

charts on page 312, showing the compressibility factor ranging from 0.2 to 3.5.

Mr. Darnell quotes several values to four digits, and some to five. Gas density is approximately equal to p/RT, and if the density is known or used to four or five digits, the implication is that both pressure and temperature are known to this degree of precision; that is, under moderate conditions, that the pressure and temperature are known to 0.1 or 0.01 psi or deg F. Since such high-precision knowledge is unusual, four and five-digit values of density are usually absurd. When Mr. Darnell's table is rounded to three digits, many of the discrepancies vanish.

Cambridge, Mass. C. HAROLD BERRY, Gordon McKay, Professor of Engineering Science, Harvard University

Comments by Kaye

In the February issue, Mr. Darnell has compared, at a given pressure and temperature, the values of the densities of various gases taken from eight different engineering handbooks. The dates of issue of these sources varied from 1916 to 1945, and yet, for most of the gases listed, the values of the densities differ but little from one source to the next. For most engineering calculations, the disagreement can be safely ignored.

If one is interested in values of gas densities which are accurate to four and five significant figures, then one cannot use the perfect gas rule in making such calculations. Instead one must depend on accurate experimental values of gas densities. In addition, it is well known that for gaseous states near the saturation line, one can introduce significant errors by using the perfect gas rule. It is for this reason that Mr. Darnell's table is in error for such gases as sulfur dioxide, ethylene, carbon dioxide, etc., if he "corrects" the listed density to another state by the method used in his examples.

Another reason for some of the minor discrepancies which Mr. Darnell has found in his comparison is that the values of the perfect gas constant have been revised, on the basis of new experimental data, several times in the period from 1910 to 1940. Hence it is not quite fair to compare densities taken from older handbooks with values taken from more recent ones.

Cambridge, Mass.

JOSEPH KAYE, Assoc. Prof. Mech. Eng., Massachusetts Institute of Technology

Editor's Note:—The only reply Mr. Darnell makes to the above comments is: "If two or three significant figures are enough, why are these values published with four significant figures in engineering books?"

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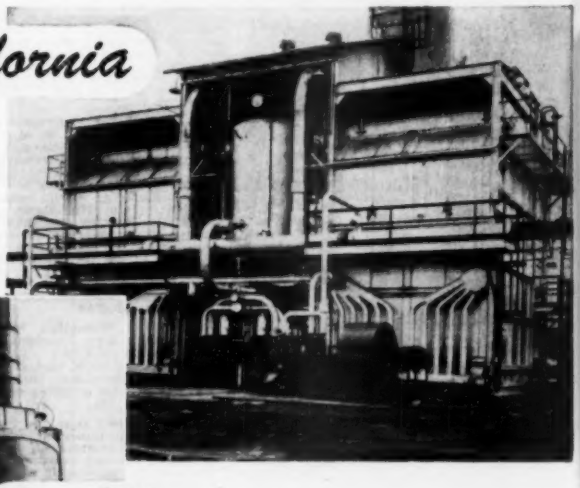

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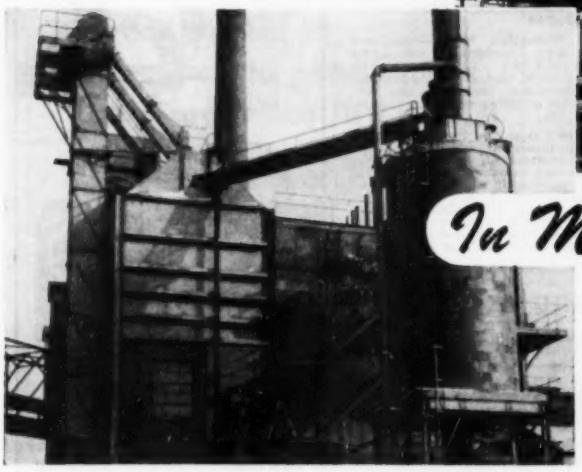

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(Continued from page 50)

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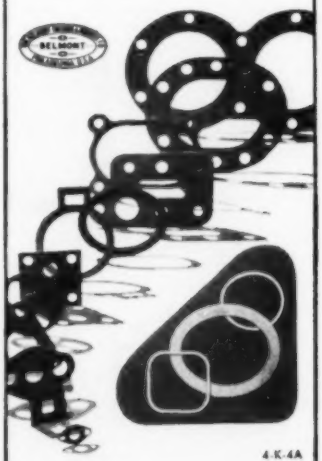

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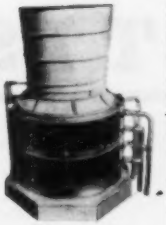

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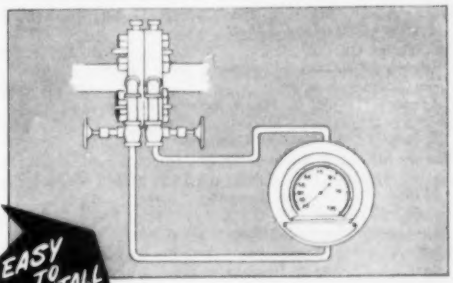

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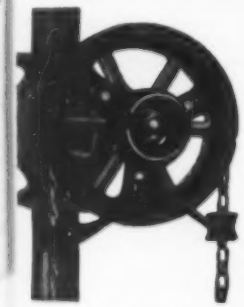
ELECTRONIC CONTROL

(Continued from page 72)

tinuous running of shaft H. The movement of nut N to the left then pivots arm 6 at 7, and since 6 is linked to Q by 8, the point 4 travels slightly to the right. This has the effect of lowering the right-hand end of the mercury switch 5 in which are fused the two contacts which are wired in series with the tractive coil of an ordinary direct-on starter controlling the stoker driving motor. When nut N is in the central position on its screw, switch 5 is so adjusted that the stoker runs for 30 sec every minute. When the nut is at the extreme left-hand end corresponding to low-pressure conditions, 5 is set to allow the stoker to run continuously. When at the extreme right, 5 allows the stoker to run for about 10 sec in every 60. This procedure has been found to provide a very wide range of coal feed rates without ever leaving the mechanical stoker completely "stopped" for more than 50 sec. It will be seen that pivot 7 is mounted on nut 9, and once set, this nut is not normally altered unless a change of coal quality necessitates an alteration to the fuel/air ratio. Should this be necessary, screw 10 is turned by wheel 11 which readjusts the running time of the stoker motor within the one-minute frequency cycle. At the extremities of the main screw M it will be seen from Fig. 1 there are two limit switches X and Y which are opened mechanically by N. These override the relays X and Y and so prevent the nut N from reaching the end of the screw.

It will be evident from the foregoing description that the electronic boiler control equipment under consideration, exhibits certain distinctive features. First, it is capable of detecting extremely small changes in pressure, second, it can be used for modulation over a wide range, and third, it can exert this modulating effect without resort to a variable speed motor. It was felt, too, that the "inching" feature whereby the mechanism tripped itself and awaited a fresh signal before proceeding, had advantages for certain applications. For example, if shaft M has to make 24 revolutions to carry the nut N from one extremity to the other, and since successive impulses of the same sense can only follow at 30 sec intervals, 12 min must elapse between a maximum and a minimum setting. This would make it impossible to reduce the draft suddenly when a "heavy or thick fire" is on the grate, a precaution which in some instances is very important. On the other hand, there are obvious situations where "inching" is undesirable, consequently it has been arranged for this feature to be omitted at will.

Since being set to work the prototype controller has undergone exhaustive tests to ascertain its ability to maintain a nearly constant steam pressure when confronted with fairly rapid and wide boiler load fluctuations. Figs. 3 and 4 show the effect of the control system at the Royal Manchester Children's Hospital. The changes in steam demand were assessed by means of a Curnan steam-flow meter, and at times these were as high as 45 per cent in the space of quarter of an hour. Under these conditions it was found that for about 36 per cent of the time the steam pressure was maintained almost exactly, at the desired figure. For 30 per cent of the run the pressure varied by no more than ½ psi from the chosen value. For the remaining 34 per cent of the test the pressure deviated from the optimum by more than ½ psi, but nevertheless, did not vary by more than 1½ psi. The stoker was of the Hodgkinson standard coking type, and at no time during the four hours duration of the test was the fire given any attention whatever. The only occasion when manual intervention was made was the cleaning of the ashpit, but the machine was left running normally and the withdrawal of ashes occupied just 1½ min; the fuel burned being a Lancashire slack. Pressure readings were taken every five minutes.



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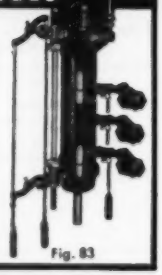

Fig. 83

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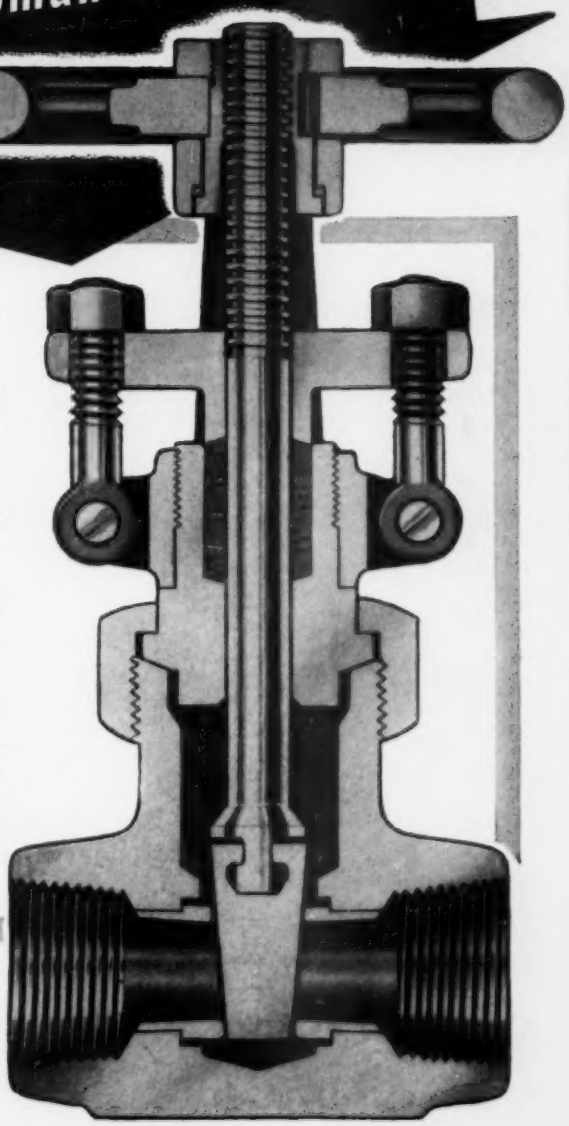

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